Insects

Eighty-fifth

ANNUAL REPORT

of the

Entomological Society

of

Ontario

1954

Published by authority of
HONOURABLE F. S. THOMAS
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CONTENTS

A COMPARATIVE STUDY OF THREE ACARICIDES[1]

THOS. ARMSTRONG[2], G. G. DUSTAN[2], and R. S. DOWNING[3]

This paper presents the results of greenhouse and orchard experiments in 1954 on the acaricidal action of three chemically related compounds, namely, p-chlorophenyl p-chlorobenzenesulphonate (Ovotran)[4], p-chlorophenyl benzenesulphonate (PCPBS)[5], and p-chlorobenzyl p-chlorophenyl sulphide (Elimite, formerly Chlorocide)[6].

Ovotran has been used commercially as an acaricide for several years and was included in these experiments for comparison with the other two materials, which were received from England late in 1953.

LITERATURE REVIEW

Kenaga and Hummer (1) reported on the early experiments with Ovotran and 21 other substituted phenyl benzene sulphonates. They concluded that the optimum ovicidal activity against the two-spotted spider mite, *Tetranychus bimaculatus* Harvey, occurred where both benzene rings were substituted with chlorine in the para position (Ovotran). Kirby and McKinlay (2) and Kirby and Read (3) found, on the contrary, that the substitution of chlorine in the para position of the phenolic ring only (PCPBS) resulted in equal or superior ovicidal activity to that of Ovotran. Armstrong (4), like the other authors mentioned, showed that Ovotran was highly toxic to the eggs of the two-spotted spider mite but relatively ineffective against the adults. Cranham *et al.* (5) described the chemical and biological properties of p-chlorobenzyl p-chlorophenyl sulphide (Elimite) and stated that it is highly toxic to the eggs and larvae of tetranychid mites, but that adult mites are apparently not affected. Blauvelt and Hathaway (5) were the first to report that eggs of the two-spotted spider mite laid on the lower surface of the leaf could be killed by K6451 (Ovotran) applied to the upper surface. This toxicity by leaf permeation was confirmed by Kirby and McKinlay (2) for both Ovotran and PCPBS against the summer eggs of the European red mite, *Metatetranychus ulmi* (Koch).

GENERAL METHODS AND MATERIALS

All the greenhouse experiments were conducted against the two-spotted spider mite on scarlet runner bean, *Phaseolus coccineus* L. A mass culture of this mite has been maintained for several years at the Vineland Station laboratory, and it has been periodically sprayed with DDT to eliminate predators. The acaricides were applied in the greenhouse with a compressed air sprayer at a pressure of 20 p.s.i. at the pump.

The European red mite was the species largely concerned in the orchard trials. The trees were sprayed either by hand-operated spray guns at a pressure of approximately 400 p.s.i. at the pump, or by an automatic air-blast sprayer.

The formulations used were those received from the manufacturers, namely, 20 or 50 per cent wettable powders, or 20 per cent emulsifiable solutions. For some experiments a 20 per cent wettable powder of Ovotran was prepared from the 50 per cent powder by mixing with pyrophillite in a ball mill.

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[1]Contribution No. 3295, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada; presented at the joint annual meetings of the Entomological Society of Canada and the Entomological Society of Ontario, Sault Ste. Marie, November 1-3, 1954.

[2]Associate Entomologist and Senior Entomologist, Entomology Laboratory, Vineland Station, Ontario.

[3]Assistant Entomologist, Fruit Insect Section, Science Service Laboratory, Summerland, B.C.

[4]Dow Chemical Company, Midland, Michigan.

[5]Murphy Chemical Company, Wheathampstead, England.

[6]Boots Pure Drug Company, Nottingham, England.

In the orchard experiments the sprays usually contained the following amounts of materials per 100 gallons: 50 per cent Ovotran wettable powder, 0.5 — 1 lb. (0.025 — 0.05 per cent spray); 20 per cent Elimite wettable powder, 0.5 lb. (0.02 per cent spray); and 50 per cent PCPBS wettable powder, 0.5 lb. (0.025 per cent spray). Where concentrate sprays were employed in the orchards, the amounts per 100 gallons were larger and the number of gallons applied per acre were correspondingly less than for the conventionally diluted sprays.

GREENHOUSE EXPERIMENTS

Ovicidal Toxicity.—Eggs of the two-spotted spider mite were obtained by placing 10 females on each of the two primary leaves of a bean plant from which all other leaves had been removed. After 48 hours, when approximately 170 — 350 eggs had been laid, the females were removed and the sprays immediately applied. Records of hatched and unhatched eggs were made 8 days later.

The results (Table I) indicate that PCPBS and Elimite are somewhat more effective ovicides than Ovotran. For example, percentage mortalities of eggs from sprays containing 0.04 per cent active ingredient were: Elimite, 94.1; PCPBS, 93.7; and Ovotran, 70.1. PCPBS was considerably more effective than the other two materials at the lower rates.

TABLE I

PERCENTAGE MORTALITIES OF EGGS OF THE TWO-SPOTTED SPIDER MITE SPRAYED WITH OVOTRAN, ELIMITE, AND PCPBS.

Pounds of 20% powder per 100 gal.	*Percentage of active ingredient in spray*	*Total eggs*	*Percentage mortality*
Ovotran			
4.0	0.08	231	80.1
3.0	0.06	177	85.3
2.0	0.04	241	70.1
1.0	0.02	232	29.3
0.5	0.01	180	18.3
0.25	0.005	223	9.9
Elimite			
4.0	0.08	274	98.9
3.0	0.06	250	98.8
2.0	0.04	306	94.1
1.0	0.02	172	51.2
0.5	0.01	173	6.4
0.25	0.005	207	9.7
PCPBS			
4.0	0.08	240	100.0
3.0	0.06	316	99.4
2.0	0.04	303	93.7
1.0	0.02	211	70.6
0.5	0.01	163	36.8
0.25	0.005	201	10.9
Check (a)	—	248	1.2
(b)	—	268	4.5

Residual Ovicidal Toxicity.—A number of bean plants with only two leaves, and from which new growth was kept removed, were sprayed at one time with 0.15 per cent Ovotran or PCPBS, or 0.08 per cent Elimite, wettable powders being used in all cases. A spray of 0.15 per cent Elimite injured bean leaves so badly that it could not be used for this test.

At intervals over a period of 45 days, plants that had been sprayed with each material were infested with eggs by placing 6 female mites on each leaf and removing them 5 days later. Seven days after the females were removed, hatched and unhatched (dead) eggs were recorded under a microscope.

The results with equal amounts of Ovotran and PCPBS (Tables II and III) show that dry spray residues of the latter were more toxic initially and retained their toxicity longer. For example, PCPBS residue from 1 to 5 days old killed 99.8 per cent of the eggs as compared to 89.2 per cent by Ovotran. After one month the mortality by Ovotran dropped to 18.1 per cent, whereas PCPBS continued to kill over 60 per cent of the eggs for over 41 days. The results with Elimite (Table IV), although not directly comparable, also show a long residual toxicity, although it dropped off more rapidly after 5 days than that of the other materials.

It should be noted that the sprays used in this experiment contained from three to six times the amounts of acaricides usually used in orchard experiments.

TABLE II

PERCENTAGE MORTALITIES OF EGGS OF THE TWO-SPOTTED SPIDER MITE LAID ON FOLIAGE SPRAYED PREVIOUSLY WITH 50 PER CENT WETTABLE OVOTRAN POWDER, 3 LB. PER 100 GAL. (0.15 PER CENT SPRAY).

Age of spray residue days	*Hatched* eggs	*Dead* eggs	*Percentage* mortality
1 to 5	85	531	86.2
8 to 11	34	512	93.8
13 to 18	52	465	89.9
20 to 22	71	582	89.1
24 to 29	106	329	75.6
31 to 36	317	70	18.1
38 to 41	135	23	14.6
43 to 45	190	19	9.1
Checks	410	56	12.0

TABLE III

PERCENTAGE MORTALITIES OF EGGS OF THE TWO-SPOTTED SPIDER MITE LAID ON FOLIAGE SPRAYED PREVIOUSLY WITH 50 PER CENT WETTABLE PCPBS POWDER, 3 LB. PER 100 GAL. (0.15 PER CENT SPRAY).

Age of spray residue days	*Hatched* eggs	*Dead* eggs	*Percentage* mortality
1 to 5	1	434	99.8
7 to 11	5	553	99.1
13 to 17	17	676	97.5
19 to 23	57	685	92.3
25 to 29	49	698	93.4
31 to 35	77	636	89.2
37 to 41	99	372	79.0
43 to 45	200	315	61.2
Checks (4)	723	23	3.1

TABLE IV

PERCENTAGE MORTALITIES OF EGGS OF THE TWO-SPOTTED SPIDER MITE LAID ON FOLIAGE SPRAYED PREVIOUSLY WITH 20 PER CENT WETTABLE ELIMITE POWDER, 4 LB. PER 100 GAL. (0.08 PER CENT SPRAY).

Age of spray residue days	*Hatched eggs*	*Dead eggs*	*Percentage mortality*
1 to 5	19	721	97.4
7 to 11	220	509	69.8
13 to 17	249	409	62.2
19 to 23	351	457	56.6
25 to 29	407	332	44.9
31 to 35	445	372	45.5
37 to 41	487	277	36.3
43 to 45	734	132	15.2
Checks (4)	831	31	3.6

Ovicidal Toxicity by Leaf Permeation.—Water suspensions of the acaricides, containing 0.1 per cent of a commercial preparation of sodium lauryl sulphate as a spreader, were painted on the upper surfaces of bean leaves. When the leaves were dry, 10 female mites were transferred to the under surface of each leaf, where they deposited approximately 200 to 300 eggs in 3 days and were then removed. Seven days after the females were removed the leaves were examined and hatched and dead eggs recorded.

The results (Table V) are in agreement with those of Kirby and Read (3) and Blauvelt and Hathaway (6) and show that all three materials can permeate the leaf and kill eggs on the opposite surface. Although reliable comparisons cannot be made from these unreplicated tests, Elimite and PCPBS appeared to be considerably more effective than Ovotran, 0.12 per cent sprays killing 76.4, 73.8, and 24.9 per cent respectively of the eggs. Emulsifiable solutions of Ovotran and Elimite were somewhat more effective than spray powders, although the differences were not consistent at all rates of dilution.

TABLE V

OVICIDAL ACTIVITY OF OVOTRAN, ELIMITE, AND PCPBS BY LEAF PERMEATION AGAINST EGGS OF THE TWO-SPOTTED SPIDER MITE.

Parts by volume or amount per 100 *gal.*	*Percentage of active ingredient in spray*	*Percentage of eggs killed by*			
		Ovotran	*Elimite*	*PCPBS*	*No Spray*
20% solution					
1—100	0.2	89.2	93.5	75.9	
1—200	0.1	76.3	72.2	56.3	
1—400	0.05	29.0	81.0	13.4	
Check	—				2.9
20% spray powder					
6.0 lb.	0.12	24.9	76.4	73.8	
3.0 lb.	0.06	26.5	54.4	54.0	
Check	—				6.8

Toxicity To Immature Mites.—Cultures of immature mites were obtained by placing 15 adult females on each of two leaves of a bean plant (Fig. 1) and removing them after 24 hours. The resulting eggs hatched in approximately 5 to 6 days, and sprays were applied a few days later when the mites were in the larval and protonymphyl stages. Mortality counts were made 3 days after spraying (Table VI).

All three acaricides were about equally effective against the larval and protonymphyl stages of the two spotted spider mite, killing over 60 per cent by 0.01 per cent sprays, and over 90 per cent by 0.04 per cent sprays, except that the PCPBS emulsifiable solution at the latter strength killed only 74.8 per cent. Spray powders of Ovotran and Elimite had approximately the same toxicity as emulsifiable solutions.

TABLE VI

PERCENTAGE MORTALITIES OF IMMATURE TWO-SPOTTED SPIDER MITES SPRAYED WITH OVOTRAN, ELIMITE, AND PCPBS.*

Parts by volume or amount per 100 gal.	*Percentage of active ingredient in spray*	*Living mites*	*Dead mites*	*Percentage mortality*
Ovotran, 20% powder				
4.0 lb.	0.08	4	86	95.6
2.0 lb.	0.04	14	127	90.1
1.0 lb.	0.02	13	104	88.9
0.5 lb.	0.01	4	186	97.9
Ovotran, 20% solution				
1—500	0.04	0	151	100.0
1—1000	0.02	16	285	94.7
1—2000	0.01	68	306	81.8
1—4000	0.005	69	124	64.2
Elimite, 20% powder				
4.0 lb.	0.08	1	113	99.1
2.0 lb.	0.04	8	104	92.9
1.0 lb.	0.02	33	95	74.2
0.5 lb.	0.01	38	88	69.8
Elimite, 20% solution				
1—500	0.04	4	157	97.5
1—1000	0.02	18	325	94.8
1—2000	0.01	95	220	69.8
1—4000	0.005	111	114	50.7
PCPBS, 20% powder				
4.0 lb.	0.08	3	123	97.6
2.0 lb.	0.04	3	110	97.3
1.0 lb.	0.02	4	151	97.4
0.5 lb.	0.01	9	115	92.7
PCPBS, 20% solution				
1—500	0.04	35	104	74.8
1—1000	0.02	44	222	83.5
1—2000	0.01	86	176	67.2
1—4000	0.005	95	49	34.0
Check — no spray (a)	—	339	2	0.6
(b)	—	330	3	0.9
(c)	—	140	5	3.4
(d)	—	192	2	1.0

*When the powders were used there were approximately 96.7 per cent protonymphs and 3.3 per cent larvae; when the solutions were used there were approximately 89.4 per cent protonymphs and 10.6 per cent larvae.

Fig. 1. Bean plant with trimmed leaves in 4-inch pot. Tanglefoot on legs keeps stray mites off plants.

Toxicity To Adult Mites.—Nearly pure cultures of adult mites were obtained by placing heavily infested and badly injured old bean plants next to new, uninfested plants so that the foliage intermingled. A day later the new plants had become well infested, the mites on the uppermost leaves being mostly adults. These leaves were cut off and placed on the test plants, to which the mites moved as the cut leaves wilted. The plants were sprayed 24 hours later and mortality was recorded 3 days after spraying.

The results (Table VII) indicate that, in spray powder form, Ovotran was much less toxic to the adults than the other two materials. For example, Ovotran at the comparatively high rate of 4 lb. of 50 per cent wettable powder per 100 gallons (0.2 per cent spray) killed only 17.7 per cent as compared to 89.9 per cent for PCPBS and 98.9 per cent for Elimite at corresponding rates. At the lower concentration of 0.05 per cent, which might be used in the orchard, PCPBS was the most effective, killing 50.9 per cent of the adults as compared to 14.7 per cent by Elimite and 10.9 per cent by Ovotran.

Table VIII shows that the order of effectiveness for emulsions was the reverse of that for wettable powders. Ovotran emulsion at 0.05 per cent strength killed 91.4 per cent and wettable powder at the same strength only 10.9 per cent. Emulsions of PCPBS were somewhat more effective than spray powders at the lower rates tested. The results with Elimite showed practically no difference between emulsions and wettable powders.

TABLE VII

PERCENTAGE MORTALITIES OF ADULTS OF THE TWO-SPOTTED SPIDER MITE SPRAYED WITH OVOTRAN, ELIMITE, AND PCPBS WETTABLE POWDERS.

Amount per 100 gal.	*Percentage of active ingredient in spray*	*Living mites*	*Dead mites*	*Percentage mortality*
Ovotran, 20% powder				
10.0 lb.	0.2	172	27	13.6
5.0 lb.	0.1	105	11	9.5
2.5 lb.	0.05	163	20	10.9
Ovotran, 50% powder				
4.0 lb.	0.2	153	33	17.7
2.0 lb.	0.1	173	25	12.6
1.0 lb.	0.05	222	29	11.6
0.5 lb.	0.025	139	17	10.9
Elimite, 20% powder				
10.0 lb.	0.2	1	89	98.9
5.0 lb.	0.1	8	120	93.8
2.5 lb.	0.05	316	50	13.7
1.25 lb.	0.025	163	28	14.7
PCPBS, 20% powder				
10.0 lb.	0.2	13	116	89.9
5.0 lb.	0.1	37	156	80.8
2.5 lb.	0.05	35	255	87.9
1.25 lb.	0.025	56	58	50.9
Check — no spray (a)	—	158	6	3.7
(b)	—	150	6	3.8

TABLE VIII

PERCENTAGE MORTALITIES OF ADULTS OF THE TWO-SPOTTED SPIDER MITE SPRAYED WIH OVOTRAN, ELIMITE, AND PCPBS SOLUTIONS

Parts by volume	*Percentage of active ingredient in spray*	*Living mites*	*Dead mites*	*Percentage mortality*
Ovotran, 20% sol.				
1—200	0.1	1	152	99.3
1—400	0.05	26	276	91.4
1—800	0.025	231	158	40.6
1—1600	0.0125	287	41	12.5
Elimite, 20% sol.				
1—200	0.1	10	97	90.7
1—400	0.05	63	80	55.9
1—800	0.025	182	30	14.2
1—1600	0.0125	171	17	9.0
PCPBS, 20% sol.				
1—200	0.1	45	186	80.5
1—400	0.05	112	48	30.0
1—800	0.025	179	8	4.3
1—1600	0.0125	193	7	3.5
Check — no spray (a)	—	145	1	0.7
(b)	—	144	6	4.0
(c)	—	164	4	2.4

ORCHARD EXPERIMENTS

Mite counts in the orchard experiments were made by brushing sample leaves in a Henderson-McBurnie (7) mite-brusher and recording the living mites. Spray injury is discussed at the end of the section on orchard experiments.

Victoria 8 *Apple Orchard, Vineland Station, Ontario.*—The object of this experiment was to compare the effectiveness of Ovotran and Elimite against the European red mite when applied at the 'pink' stage, May 15, and at the first 'cover', June 16. The test was conducted on single-tree plots of Red Delicious apple replicated 4 times, and the sprays were applied by a hand-operated spray gun. These trees also received the regular captan — DDT sprays recommended for Ontario, applied with an automatic air-blast sprayer by the Ontario Horticultural Experiment Station.

Results were taken by counting all living stages of the mites, except eggs, from 50 leaves per tree. Fig. 2 shows that 20 per cent Elimite wettable powder at 1 lb. and 50 per cent Ovotran wettable powder at 0.5 lb. per 100 gallons each gave effective control of this comparatively light infestation of the mite. At the time of the peak population on July 26 the populations per leaf were: Elimite, 0.39; Ovotran, 0.70; and check, 9.8.

Fig. 2. Populations of the European red mite on apple, Victoria 8 orchard, Vineland Station, Ontario.

The four-spotted spider mite, *Tetranychus canadensis* (McG.), appeared on the trees in mid July and by August 19 was present in the following numbers per leaf: Ovotran, 13.9; Elimite, 18.2; and check, 28.9. It is obvious that these early-season sprays did not give adequate control of this species.

McGibbon Apple Orchard, Oliver, B.C.—This Red Delicious apple orchard was infested in 1953 with strains of the European red mite resistant to malathion and parathion. On May 4, 1954, a 'pink' spray was applied with a Trump A.S. 13 concentrate sprayer applying 100 gallons per acre.

The results (Table IX) show good control by all three materials. The build-up in population in September did not result in appreciable injury to the foliage, although many winter eggs were laid.

TABLE IX

CONTROL OF THE EUROPEAN RED MITE ON RED DELICIOUS APPLE, MCGIBBON ORCHARD, OLIVER, B. C.

Material per acre		*Average number of mites per leaf*				
		May 18	*June* 11	*July* 9	*Aug.* 10	*Sept.* 9
20% Elimite Lime-sulphur,	16 lb. 8 gal.	0.00	0.03	0.06	0.34	5.79
50% PCPBS, Lime-sulphur,	8 lb. 8 gal.	0.00	0.04	0.08	0.34	6.95
50% Ovotran, Lime-sulphur,	8 lb. 8 gal.	0.03	0.05	0.07	1.03	9.14
Check — no treatment		3.71	18.68		Trees sprayed	

On June 14, the check plot was divided in half and 20 per cent Elimite, 1 and 2 lb. per 100 gallons respectively, was applied to each half. Mite populations on July 9, August 10, and September 9, were: 1-lb. rate, 0.21, 1.59, and 1.98 respectively; and 2-lb. rate, 0.21, 0.21, and 0.26 respectively.

Powell Orchard, Summerland, B. C.—This orchard, of Delicious apples interplanted with Bartlett pears, was also infested with strains of the European red mite resistant to malathion and parathion. A 'pink' spray was applied on May 13 with a Trump A. S. 13 concentrate sprayer using the materials shown in Table X. The owner of the orchard applied lime-sulphur at 8 gallons per acre to all plots on May 15.

TABLE X

CONTROL OF THE EUROPEAN RED MITE ON RED DELICIOUS APPLE AND BARTLETT PEAR, POWELL ORCHARD, SUMMERLAND, B. C.

Material per acre		*Average number of mites per leaf*				
		May 27	*June* 24	*July* 15	*Aug.* 12	*Sept.* 13
20% Elimite,	16 lb.	0.14	0.12	0.02	0.45	0.69
50% Ovotran,	8 lb.	0.01	0.30	0.07	1.26	5.03
50% Ovotran,	4 lb.	0.08	0.07	0.09	1.42	2.91
Check — no treatment		3.00	19.66		Trees sprayed	

There was no appreciable difference in the good control by 50 per cent Ovotran at 4 and 8 lb. per acre. 20 per cent Elimite at 16 lb. per acre was slightly more effective than Ovotran. (See later discussion of spray injury).

Hohn Orchard, Kaledon, B.C.—This orchard, of Newtown and a few Delicious apple trees, was heavily infested with malathion-resistant European red mites in July. Observations on July 29 indicated a population of approximately 30 mites per leaf. Sprays (Table XI) were applied on July 30 with a concentrate sprayer.

On August 6, one week after spraying, observations showed that many adult mites were still feeding in the plots sprayed with PCPBS or Elimite alone, but very few where Aramite had been added. By August 13, when the first count was made, good control of all stages of the mites had been secured in all plots.

TABLE XI

CONTROL OF THE EUROPEAN RED MITE ON NEWTOWN AND DELICIOUS APPLES, HOHN ORCHARD, KALEDON, B. C.

Material per acre		*Average number of mites per leaf*	
		Aug. 13	*Aug.* 27
50% PCPBS,	4 lb.	0.21	0.04
50% PCPBS, 15% Aramite,	4 lb. 6 lb.	0.15	0.01
20% Elimite,	10 lb.	0.73	0.01
20% Elimite, 15% Aramite,	10 lb. 6 lb.	0.84	0.00
Check		23.44	0.74

Corbishley Orchard, Penticton, B. C.—Fifty per cent PCPBS wettable powder at 4 lb. per acre was applied alone and with 15 per cent Aramite wettable powder at 6 lb. per acre in July to control a heavy infestation of the European red mite attacking Jonathan and McIntosh apple trees. The sprays were applied with a concentrate sprayer at 100 gallons per acre.

Excellent initial and residual control was obtained with the mixture of Aramite and PCPBS, but with the latter alone adequate control was not evident until two weeks after application.

H. E. S. 8 *Plum Orchard, Vineland Station, Ontario.*—The control of the European red mite by Elimite and PCPBS was compared in unreplicated plots in this orchard, which contained about 12 varieties of plums and prunes. Twenty per cent Elimite at 1 lb. and 50 per cent PCPBS at 0.5 lb. were added to the regularly used lead arsenate at 4 lb. and wettable sulphur at 7 lb. per 100 gallons in both the 'shuck' spray on June 1 and 2 and the '10-day' spray on June 14. The results were taken on the Italian prune variety only, and these (Table XII) show a high degree of control by both materials. Ovotran had been used in this orchard equally successfully in previous years.

Platts Plum Orchard, Vineland Station, Ontario.—The control of the European red mite in this Italian prune orchard by Elimite, parathion, and malathion was compared in unreplicated plots without an untreated check. Twenty per cent Elimite wettable powder was used at 2 lb. per 100 gallons, with 50 per cent dieldrin wettable powder at 0.75 lb. in one plot, and with lead arsenate at 4 lb. in the other. The other two plots received 15 per cent parathion wettable powder at 1.25 lb. and 25 per cent malathion wettable powder at 2 lb. respectively. Colsul (colloidal) sulphur at 8 lb. per 100 gallons was added to all sprays. The sprays were applied twice, at the 'shuck' stage on May 31, and on June 10 and 12.

TABLE XII

CONTROL OF THE EUROPEAN RED MITE ON ITALIAN PRUNE,
H. E. S. 8 ORCHARD, VINELAND STATION, ONTARIO.

Material per 100 gal.		*Average number of mites per leaf*					
		June 22	*July* 7	*July* 21	*Aug.* 5	*Aug.* 19	*Sept.* 1
20% Elimite,	1 lb.	0	0	0	0.08	0.50	0.26
Lead arsenate,	4 lb.						
Wettable sulphur,	7 lb.						
50% PCPBS,	0.5 lb.	0	0.06	0.06	0.54	0.14	2.48
Lead arsenate,	4 lb.						
Wettable sulphur,	7 lb.						
Check — no treatment		0.46	1.52	13.64	117.80	31.00	0.12

Counts on the same dates as in the H. E. S. 8 orchard showed almost perfect control of the European red mite by all materials. There was a slight build-up in population in late August but the maximum number of mites per leaf did not exceed 0.56 in any plot.

Janzen Elberta Peach Orchard, Port Dalhousie, Ontario.—A population of the European red mite in this orchard averaging approximately 20 active stages per leaf in July afforded an opportunity to compare Elimite, Ovotran, and PCPBS in two sprays applied on July 9 and 23. The acaricide sprays were applied at about 4 gallons per tree by hand-operated guns with 20 per cent Elimite wettable powder at 1 lb., 50 per cent Ovotran wettable powder at 0.5 lb., and 50 per cent PCPBS wettable powder at 0.5 lb. per 100 gallons. The checks were sprayed with water. All plots had been sprayed a few days previously with DDT and sulphur by a concentrate sprayer.

Single-tree plots replicated 6 times in randomized blocks were used for the experiment. Fifty leaves per tree were examined for mites on each of the dates shown in Table XIII.

The results again show no apparently significant difference in the control by the acaricides, although PCPBS gave a somewhat faster reduction in the population. The control of this population was satisfactory but if the initial population had been heavier the slow kill by the first spray might have resulted in serious mite injury, unless a quick-acting acaricide such as Aramite had been added.

TABLE XIII

CONTROL OF THE EUROPEAN RED MITE ON ELBERTA PEACH,
JANZEN ORCHARD, PORT DALHOUSIE, ONTARIO.

Material per 100 gal.	*Average number of mites per leaf*							
	July 9	*July* 14	*July* 21	*July* 27	*Aug.* 4	*Aug.* 9	*Aug.* 16	*Sept.* 9
50% Ovotran, 0.5 lb.	15.5	3.8	7.5	2.4	0.9	1.0	0.2	1.9
20% Elimite, 1. lb.	19.1	5.6	3.4	2.1	1.0	1.0	0.3	0.7
50% PCPBS, 0.5 lb.	21.5	4.6	2.6	1.4	0.6	0.8	0.4	0.6
Check — water	21.0	11.3	16.8	15.5	17.7	19.5	15.8	4.7

PHYTOTOXICITY

Kirby *et al.* (8) reported that a 0.05 per cent spray of PCPBS caused a small amount of injury to the flower trusses and spur tissue of Worcester Pearmain apple following applications at the pink and petal-fall stages of growth. The manufacturer of this material stated (in litt.) that in some orchards in England PCPBS had caused serious cracking of the fruit and one-year old bark of Worcester Pearmain, and that similar injury occurred on Golden Delicious apple in New Zealand. Serious injury of this type has not occurred in Canada.

Ovotran has been used for several years on apple, peach, and plum and no injury has been observed in Eastern Canada. In British Columbia, early-season applications have caused some burning of the tender leaves of apple.

One application on May 29 of a 0.4 per cent spray of Elimite caused no injury on apple in Nova Scotia. In Ontario, none of the various varieties of apple, plum, and peach in the present experiments were injured.

In British Columbia the spray on May 13 caused severe injury to about 40 per cent of young fruits of Bartlett pear in the Powell orchard where Ovotran was used at 8 lb. per acre. The injury appeared two weeks after the application as large black sunken areas at the calyx end of the fruit. Ovotran at 4 lb. per acre injured only about 1 per cent of the fruit. In this orchard, slight spotting occurred on the foliage of Delicious apple where Ovotran at 8 and 4 lb. or Elimite at 16 lb. per acre were applied on May 13, but the injury by the lower rate of Ovotran was barely noticeable.

In the McGibbon orchard 'pink' sprays on May 4 of Ovotran, Elimite, and PCPBS caused no injury on Red Delicious apple, but Elimite at 2 lb. per 100 gallons applied on June 14 caused lenticel corking (small brown spots) on the skin of about 5 per cent of the fruit. Elimite at 1 lb. per 100 gallons caused no injury.

In the Hohn orchard, PCPBS at 4 lb. per acre applied on July 30 caused a lenticel type injury on Newtown but not on Delicious apple. The injury appeared on the Newtown fruit one month after the spray application in the form of dark-green spots that later turned brown and necrotic. Elimite at 10 lb. per acre caused no injury in this orchard.

A July spray in the Corbishley orchard of PCPBS at 4 lb. per acre caused about 2 per cent defoliation of Jonathan apple trees but did not injure McIntosh. No injury was noticed where Aramite at 6 lb. per acre was used with the PCPBS in this orchard although the addition of Aramite did not prevent the lenticel type injury in the Hohn orchard.

A 'pink' spray was applied on May 6 to Delicious, Newtown, McIntosh, and Winesap apple trees in the Berryman orchard, Penticton, B.C. Necrotic spots on the foliage of all varieties occurred where Elimite at 8 or 16 lb. or Ovotran at 8 lb. per acre was applied. A much smaller amount of injury was caused by Ovotran at 4 lb. per acre. PCPBS at 8 or 16 lb. per acre caused no injury.

Conclusions on the relative safety to fruit trees of Ovotran, Elimite, and PCPBS cannot be drawn until further experiments have been conducted.

SUMMARY

In greenhouse experiments against the two-spotted spider mite, PCPBS, Elimite, and Ovotran were highly effective ovicides. The residual ovicidal action on bean foliage remained high for approximately a month and was longer for PCPBS than for the other two materials at rates recommended for orchard use. Toxicity to eggs by leaf permeation was demonstrated for each acaricide; emulsions of Ovotran were more effective than wettable powders in killing eggs on the opposite, untreated surface of a leaf.

All three materials were about equally toxic to protonymphs and larvae, killing over 75 per cent at rates of dilution recommended for orchards. PCPBS in emulsion form was considerably less toxic than as a wettable powder to these immature forms. Elimite and Ovotran were only slightly toxic to the adults in the greenhouse at rates normally used in the field, whereas PCPBS killed relatively high percentages. Ovotran emulsion was more toxic than the wettable powder to the adults.

In field experiments on apple, peach, and plum, the three acaricides gave about the same high degree of control of the European red mite. One or two early-season sprays shortly before and after bloom often gave good commercial control for the season. Because of the relative in-

effectiveness against adults, sprays applied to well-established populations in July often did not give good control for two weeks, unless a quick-acting acaricide such as Aramite was added.

No foliage or fruit injury was caused in Ontario in limited field trials on apple, peach, and plum. In British Columbia, Ovotran applied at the pink stage caused serious injury to Bartlett pear fruitlets and slight foliage injury on some varieties of apple. Elimite at the pink stage occasionally caused slight injury, but PCPBS did not. Elimite applied in mid June caused lenticel corking on a small percentage of the fruit in one Red Delicious apple orchard. PCPBS applied in July caused a lenticel type of injury on Newtown apple but not on Delicious, and, in a second orchard, about 2 per cent defoliation of Jonathan apple but not of McIntosh.

ACKNOWLEDGMENTS

The authors wish to thank Messrs. R. C. Miller, and C. M. Simpson for carrying out some of the spraying operations and Mr. D. C. Herne for assisting in the mite counts.

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SCREENING NEW COMPOUNDS AS INSECTICIDES. A PROGRESS REPORT

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INTRODUCTION

Last year we described the methods and apparatus used for the rapid screening of new compounds for insecticidal efficiency against aphids (See Musgrave and Kukovica, 1953). During the past year a further 300 compounds have been screened and the technique has been extended and elaborated.

ELABORATIONS AND EXTENSIONS IN TECHNIQUE

Our screening tests now include an assessment of the residual effect and phytotoxicity of the compounds. By residual effect we mean the toxicity manifested when insects walk over a treated surface sometime after it has been sprayed. Phytotoxic effect has been gauged as the extent and degree of damage to the plant foliage. An assessment of both these effects can be obtained by the same method, which is as follows. Bean plants in small two inch plant pots are sprayed in the Potter tower (see Musgrave and Kukovica, 1953) by slightly modifying the base plate. The soil in the pots is protected by being covered with filter paper, slotted so that it can slide past the bean stem. Aphids are then constrained to walk over the sprayed surfaces by being placed in our lantern globe cages which are then inverted over the beans in the pots.

The bean plants can be subjected to test at any time after being sprayed so that the duration of residual effect can be measured. Possible fumigant effect by volatile compounds is unlikely as the lantern globe cages are covered by air-permeable cheese cloth. The method is suitable only for screening compounds as it does not permit of any precise control over the dose.

MATERIALS AND METHODS

A list of the compounds tested is given at the end of this paper. Not all were tested for residual effect and phytotoxicity as the methods for these were elaborated during the year. Most of the compounds were carried in a benzene/water emulsion containing 5% of benzene, but some, whose benzene solubility was low, were dissolved in acetone or acetone and water mixed (60% acetone, 40% water). The benzene emulsion was emulsified by means of an emulsifying agent Emulfor E. L. which is a condensation product of castor oil and ethylene oxide (a polyethylether).

All compounds were tested as 1% of the sprayed material unless otherwise indicated. One millilitre volumes were used for direct spray; 2 ml. volumes to obtain residual effect. One millilitre of spray material deposited a mean weight over the year of 0.013 mgm./mm^2 of surface with benzene emulsion and 0.006 mgm./mm^2 of surface in acetone/water. Because of its high volatility pure acetone was found to be difficult to regulate as to dose and was avoided as a carrier whenever possible.

As described previously (Musgrave and Kukovica, 1953) a BHC treatment was included in every experiment as a check on the susceptibility of the aphids. The BHC check was made from "Higam 99" (of the Philadelphia Salt Co.) which contains 99% gamma isomer. It was incorporated in the standard benzene emulsion (5% benzene) so as to give an emulsion containing 0.05% benzene hexachloride.

RESULTS

Some degree of species specificity was discernable among the compounds.

The following compounds effected 100% mortality to *Aphis fabae:*
p-Chlorophenyl β-thiocyanoethyl sulfide (in benzene emulsion and acetone/water).
2,3,5-Trichlorophenyl-mercaptoethyl thiocyanate (in acetone/water).
1-p-Chlorophenyl-2,3-dithiocyanopropyl sulfide (in benzene emulsion).
bis β-Thiocyanoethyl p-xylylene ether (in benzene emulsion).
Thiocyanoethyl thiocyanoacetate (in benzene emulsion).
Mercaptodiethyl bis (chloroacetate) (in benzene emulsion).

The following compounds caused 100% mortality to *Macrosiphum pisi:*
p-Chlorophenyl mercaptoethyl chloride (in acetone).
p-Chlorophenyl β-thiocyanoethyl sulfide (in benzene emulsion and acetone/water).
Thiocyanoethyl thiocyanoacetate (in benzene emulsion).

Forty-five compounds were tested for residual effect; of these, 8 caused about 50% mortality and the following 5 caused 100% mortality (all in benzene emulsion):
p-Chlorobenzyl β-chloroethyl ether.
p-Chlorobenzyl β-thiocyanoethyl ether.
5,8-Dichloroquinoline.
3,4-Dichlorobenzyl chloroethyl ether.
2,5-Dichlorobenzyl-2-chloroethyl ether.

Forty-five compounds were tested for phytotoxicity. Many of them showed some phytotoxicity but only one was highly phytotoxic; it was:
1,4-Chloronaphthalene sulfochloride (in benzene emulsion).

The most toxic compound screened during the year was:
p-Chlorophenyl β-thiocyanoethyl sulfide (in benzene emulsion).
It was, unfortunately, phytotoxic.

The compounds listed at the end of this paper are placed in three groups:
Group A — those producing less than 40% mortality;
Group B — those producing 40 to 60% mortality; and
Group C — those giving more than 60% mortality; the natural mortality of the populations under test being satisfactory in each instance and usually less than 15%.

Mean natural mortality for the period under review was: 0.88% in *M. pisi;* 7.0% in *A. fabae* in 121 tests by the direct spray technique. The results with the emulsion check indicate that, while the benzene emulsion may have contributed to such toxicity as was shown by compounds in Groups A and B, it did not contribute materially to those listed under Group C.

REMARKS

The results of the work described in these pages do not, as yet, permit of any useful theorising. They are published to keep others in the field informed of compounds screened. It is of interest that the most toxic compound was a "thiocyano-" compound. The organic thiocyanates have, of course, been known as good insecticides for some years (*vide,* e.g. Brown, 1951; and Callaway and Musgrave, 1940). The work is undergoing further expansion.

ACKNOWLEDGEMENTS

The compounds tested were synthesized by Dr. M. Kulka and Dr. F. Stryk of the Dominion Rubber Company Research Laboratories in Guelph. They have published details of the chemistry of some of the compounds elsewhere, (Kulka, 1954, 1955; Kulka & Stryk, 1955). We are grateful to them for their co-operation.

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LIST OF COMPOUNDS TESTED BY DIRECT SPRAY

Group A

3-Nitro-4,n-butoxybenzyl β-chloroethyl ether
3-Nitro-4,β-bromoethoxybenzyl β-chloroethyl ether
3-Nitro-4-dodecyloxybenzyl β-chloroethyl ether
p-tert.-Butyl phenoxyethyl benzyl ether
2,4-Dichlorophenoxyisopropyl benzyl ether
Phenoxymethyl β-chloroethyl ether
Pentachlorophenoxymethyl β-chloroethyl ether
2,4-Dichlorophenoxymethyl β-chloroethyl ether
p-tert.-Butylphenoxymethyl β-chloroethyl ether
p-tert.-Butylphenoxymethyl β-p-tert.-butylphenoxyethyl ether
p-Chlorophenoxymethyl β-2,4-dichlorophenoxyethyl ether
α-Naphthoxymethyl β-chloroethyl ether
p-Chlorophenoxymethyl β-chloroethyl ether
p-Chlorophenoxymethyl β-dimethylaminoethyl ether
p-Chlorophenoxymethyl β-chloropropyl ether
p-Chlorophenoxymethyl β-dimethylaminoethyl ether ethyl hydroxide
p,p'-Dinitrodiphenyl ether
p,p'-Dibromodiphenyl ether
p-Nitrophenoxymethyl β-chloroethyl ether
p-Nitrophenoxymethyl β,N-morpholinoethyl ether
p-Nitrophenoxymethyl β,N-morpholinopropyl ether
p-Nitrophenoxymethyl β-thiocyanoethyl ether
p-Nitrophenoxymethyl β-thiocyanopropyl ether
2,4-Dinitrophenoxymethyl β-chloroethyl ether
p-t-Butylphenyl β-chloroethyl ether
p-t-Butylphenoxyethyl allyl ether
p-t-Butylphenoxyethyl β-chloroethoxymethyl ether
p-t-Butylphenoxyethyl β-thiocyanoethoxymethyl ether
p-t-Bptylphenoxyethyl β-chloropropyl ether
bis (p-t-Butylphenoxyethyl) ether
p-4-Nitrophenoxybenzyl β-chloroethyl ether
p-Xylylene bis (p-chlorophenyl) ether
2-Chloromethyl-4-chlorophenyl β-chloroethyl ether
1-p-Chlorophenyl 2-hydroxy-3-chloropropyl ether
p-Chlorophenyl β-chloroethyl ether
2,4-Dichlorophenyl β-chloroethyl ether
o-Chlorobenzyl β-chloroethyl ether
p-Chlorobenzyl β-chloroethyl ether
p-Chlorobenzyl β-thiocyanoethyl ether
2,5-Dichlorobenzyl 2-chloroethyl ether
2,4-Dichlorobenzyl 2-chloroethyl ether
Pentachlorobenzyl 2-hydroxyethyl ether
2-Thiocyanomethyl-4-chlorophenyl β-thiocyanoethyl ether
bis (2-Thiocyanoethyl) ether
3-Nitro-4-methvlbenzyl β-thiocyanoethyl ether
3-Nitro-4-methoxybenzyl β-thiocyanoethyl ether
2,5-Dichloro p-xylylene bis-2-chloroethyl ether
3-Chloro-5,β-chloroethoxybenzyl 2-chloroethyl ether
2,4-bis (N-tetrahydroquinolyl sulfonyl)-1-chlorobenzene
c,β-Bromoethoxvnitrobenzene
o,n-Butoxynitrobenzene
o-Allyloxynitrobenzene
o,n-Dodecyloxvnitrobenzene
p-β-chloroethylbenzene
1,3,5- (Trichlorotriacetyl) benzene
m-bis (β-Chloroethoxymethoxy) benzene
bis (p-β-Chloroethoxymethoxy) benzene
bis (o-β-Chloroethoxymethoxy) benzene
1,2,3,-tris (β-Chloroethoxymethoxy) benzene
3,4-Dimethoxynitrobenzene
Dichloroazoxybenzene
p-Nitro β-chloroethylbenzene
p-Nitrocylcopentyloxybenzene
1,2-Dichloro-4,5-dinitrobenzene
4-Chloro-1,3-dithiolbenzene

1,3-Dimethyl-4,6-bis (β-hydroxyethoxymethyl) benzene
1,3-Dimethyl-4,6-bis (β-chloroethoxymethyl) benzene
1,4-bis (β-Hydroxyethoxymethyl)-2,5-dichlorobenzene

3-Nitro-4,β-bromoethoxy benzyl chloride
3-Nitro-4,n-butoxybenzyl chloride
3-Nitro-4-dodecyloxybenzyl chloride
3-Nitro-4,5-dimethoxybenzyl chloride
3-Bromo-4-methoxybenzyl chloride
Diphenyliodium chloride
4,4'-Dichlorodiphenyliodium chloride
p-4-Nitrophenoxybenzyl chloride
o-Nitrophenyl sulfur chloride
Benzophenone dichloride
S-p-Chlorobenzyl thiuronium chloride
S-p-Xylylene, bis thiuronium chloride
S-2-Nitro-4,5-dimethoxybenzyl thiuronium chloride
S-Pentachlorobenzyl thiuronium chloride
Pentachlorobenzyl chloride
2,5-Dichloro-p-xylylene bis-S-thiuronium chloride
2,5-Dichlorobenzyl chloride
Chlorinated p-Xylylene dichloride
3-Nitro-4-methoxybenzyl chloride
1,4-Chloronaphthalene sulfochloride

o-Ethylphenyl β-chloroethyl sulfide
o-Isopropylphenyl β-chloroethyl sulfide
Phenyl β-chloroethyl sulfide
2,5-Dichlorophenyl β-chloroethyl sulfide
2,3,5-Trichlorophenyl β-chloroethyl sulfide
p-Nitrophenyl β-chloroethyl sulfide
bis β-Chloroethyl chlorobenzene 2,4-disulfide
p-Chlorophenyl hydroxyisopropyl sulfide
p-Chlorobenzyl p-chlorophenyl sulfide
p-Chlorophenyl 2,3-dichloropropyl sulfide
p-Chlorobenzene β-chloroisopropyl sulfide
p-Nitrophenyl β-chloroethoxymethyl sulfide
o-Nitrophenyl β-thiocyanoethyl sulfide
2,4,5-Trichlorophenyl thiocyanoethyl sulfide
bis (2-Thiocyanoethyl) sulfide
bis-β- (p-Chlorophenylmercaptoethyl) sulfide
1,3-Chloromethyl-2-chlorophenyl-4-chloroethyl sulfide
bis (2-Mercaptothiozolylethyl) sulfide
p-Chlorophenyl 2,3-bis (thiocyanopropyl) sulfide
p-Chlorophenyl-3-chloro-2-bromopropyl sulfide
bis (2-Methoxy-4-formylphenoxyethyl) sulfide
bis (2-Bromo-4-t-butylphenoxyethyl) sulfide
2-Chloromethyl-4-chlorophenyl-β-chloroethyl sulfide
p-Chlorobenzyl-1- (2-hydroxynaphthyl) methyl sulfide
2-β-Chloroethoxymethoxy-1-naphthyl methyl benzyl sulfide
α-Chloronaphthyl-β-chloroethyl sulfide

bis-n-Dodecylsulfite
bis-o-Isopropylphenyl sulfite
bis-p-Chlorophenyl sulfite
bis-1,1'-Dinaphthyl sulfite
bis-p-tert. Butylphenoxyethyl sulfite
bis-Carbethoxyethyl sulfite

p-Chlorophenyl p-anisyl sulfone
Dimethyl chlorobenzene-2,4-disulfone
β-Hydroxyethyl p-chlorophenyl sulfone
Dimethyl phenoxybenzene 4,4-disulfone
bis (Chloromethyl) phenoxybenzene 4,4'-disulfone

8-Quinolyl p-chlorobenzene sulfonate
bis (8-Quinolyl) chlorobenzene-2,4-disulfonate
m. Methoxyphenyl p-chlorobenzene sulfonate
Diethyl chlorobenzene-2,4-disulfonate
bis (p-Chlorophenyl) chlorobenzene-2,4-disulfonate

bis (p-Nitrophenyl) chlorobenzene-2,4-disulfonate
p-tert. Butylphenoxyethyl p-chlorobenzene sulfonate
Phenoxyethyl p-chlorobenzene sulfonate
Phenyl p-chlorobenzene sulfonate
β-Chloroethyl p-chlorobenzene sulfonate
bis-p-Chlorophenylphenoxybenzene-4,4'-disulfonate
2,6-Dibromophenyl p-chlorobenzene sulfonate

2-Methoxy-5-t-butyl-4'-chlorobenzophenone
2-Methoxy-5-t-butylbenzophenone
o-Methoxybenzophenone
o-Methoxy-p'-chlorobenzophenone
2-Methoxy-3'-bromobenzophenone
2-Methoxy-5-tert.-butyl-3'-bromobenzophenone
2-Methoxy-5-tert.-butyl-2'-bromobenzophenone
2-Methoxy-4'-methylbenzophenone
2-Methoxy-5-tert.-butyl-2'-chlorobenzophenone
2,4-Dimethoxybenzophenone
2,4-Dimethoxy-5-tert.-butylbenzophenone
2,2'-Dimethoxy-5-tert.-butylbenzophenone
2,4'-Dimethoxybenzophenone
2,4'-Dihydroxybenzophenone
2-Hydroxy-2'-chlorobenzophenone
2-Hydroxy-4'-chlorobenzophenone
2-Hydroxy-3'-bromobenzophenone
2-Hydroxy-5-tert.-butyl-2-bromobenzophenone
2-Hydroxy-5-tert.-butylbenzophenone
2-Hydroxy-2'-chloro-5-tert.-butylbenzophenone

2-Hydroxy-2'-bromoacetophenone
2-Hydroxy-3,5-dichloroacetophenone

o-Isopropyl phenol
o,o'-bis (β-Chloroethoxymethyl) isopropylidine bis-phenol
2,6-Dichloro-4-t-butyl phenol
Polychlorinated p-t-butyl phenol
2,6-Dibromo-4-t-butyl phenol
2-Bromo-4-t-butyl phenol
2-Chloro-4-t-butyl phenol
2-Acetyl-4-chlorophenol

thiophenol
o-Ethyl thiophenol
o-Isopropyl thiophenol
p-tert.-Butyl thiophenol
p-Nitrothiophenol
p-Chlorothiophenol
3,4-Dichlorothiophenol
2,5-Dichlorothiophenol

2-p-Chlorophenoxyethanol
2-Phenylmercaptoethanol
o-Ethylphenyl mercaptoethanol
o-Isopropyl mercaptoethanol
p-Chlorophenyl mercaptoethanol
p-Nitrophenyl mercaptoethanol
3,4-Dichlorophenyl mercaptoethanol
2,5-Dichlorophenyl mercaptoethanol
2,3,5-Trichlorophenyl mercaptoethanol
Chlorobenzene-2,4-di-β-mercaptoethanol
2,6-Dibromo-4-t-butylphenoxyethanol
β- (p-Chlorobenzyloxy) ethanol

o-Isopropyl phenoxy ethane
1,2-bis (o-Nitrophenoxy) ethane
1,2-bis (2,4-Dichlorophenoxy) ethane
1,2-bis (p-Chlorophenoxy) ethane
1,2-bis (2,5-Dichlorophenyl mercapto) ethane

1,2-Dithiocyanatoethane
1,2-bis (Mercaptobenzothiazolyl) ethane
1-Thiocyanato-2-bromoethane

2-Methoxy-5-t-butyl-4'-chlorodiphenyl methane
2-Methoxy-4'-chlorodiphenyl methane
2,4-Dimethoxy-5-t-butyl-3'-nitrodiphenyl methane
4,4'-Dimethoxy-3,3'-dinitrodiphenyl methane

1-p-Chlorophenyl mercapto-2-hydroxy-3-chloropropane
1-p-Chlorophenoxy-2-thiocyano-3-chloropropane
1,3-Dichloro-2-p-chlorophenoxymethylpropane
1,3-Dithiocyanato-2-p-chlorophenoxymethoxypropane
1,1,3-Tributoxy-3-chloropropane

2-Methyl-4-hydroxy-6-chloroquinoline
2-Methyl-4,6-dichloroquinoline
N,p-Chlorobenzenesulfonyl-1,2,3,4-tetrahydroquinoline
N-Methyl-tetrahydroquinoline
7-Nitro-1,2,3,4-tetrahydroquinoline
6-Nitro-1,2,3,4-tetrahydroquinoline
5,8-Dichloro-6-nitroquinoline

7-Hydroisoquinoline
1-Cyano-2-benzoyl-1,2-dihydroisoquinoline

o-Methoxybenzophenone oxime
2-p-Chlorobenzoyl-4-tert.-butylanisole oxime
2-Benzoyl-4-tert.-butylanisole oxime

bis (Δ-Butyraldiethylacetal) amine
2-β-Chloroethoxy-5-chloro-N, β-hydroxyethyl benzylamine
2-Bromo-4,5-dimethoxyphenylethylamine
Acetoacetyl cyclohexylamine

2-Thiono-5,5-dimethyl-4-oxazolidinone
2-Thiono-5,p-chlorophenyl-4-oxazolidinone

2-Methyl thiazole
4-Methyl thiazole
2,4-Dimethyl thiazole

1,4-Dichloronaphthalene
1-Chloro-4-bromonaphthalene
1-Chloro-4-iodonaphthalene

3,4-Dimethoxybenzyl cyanide
p- (4-Nitrophenoxy) benzyl cyanide
3-Amino-4-methoxybenzyl cyanide

2,5-Dichlorophenyl mercaptoethyl thiocyanate
3,4-Dichlorophenyl mercaptoethyl thiocyanate
p-Chlorophenoxyethyl thiocyanate
p,p'-Dichlorobenzhydryl thiocyanate

β-Chloroethyl chloroacetate
2-Thiocyanoethyl p-chlorophenoxy acetate
β-Chloroethyl p-chlorophenoxy acetate
2-Chloroethyl thiocyanoacetate

Allyl p-t-butylphenoxyethyl xanthate
Ethyl p-t-butylphenoxyethyl xanthate
Sodium p-t-butylphenoxyethyl xanthate

Crotonaldehyde cyanohydrin benzoate
p-tert.-butylphenyl benzoate
2,2,4-Trimethyl-α-hydroxy-β,β,β-trichloroethyl mercapto pentane
4-Methyl-4-nitro pentanal
1,N,N,N',N'-Pentachlorobenzene-2,4-disulfonamide
Chlorobenzene-2,4-disulfonhydrazide
p-Chlorophenoxymethyl β-dimethylaminoethyl ether ethiodide
Morpholinoethyl p-chlorophenoxymethyl ether ethiodide
p-Chlorophenoxymethyl β-dimethylaminoethyl ether butiodide
p-Chlorophenoxymethyl β-dimethylaminoethyl ether buthydroxide
β-Chloroethoxymethyl vanillin
O,O-bis (β-Chloroethoxymethyl) tetrachlorohydroquinone
Aminobutyral diethyl acetal
o-Chlorobenzaldehyde β-chloroethyl acetal
p-Chlorotoluene
3-Amino-4-methoxy-6-chlorotoluene
p-Chloro-ω-nitro styrene
p-Chlorophenyl mercaptoethyl morpholide
Xanthone
3,4-Dimethoxybenzyl alcohol
Ethyl β-p-chloroanilinoacrylate
Glycolonitrite
Acetone cyanohydrin
Ethyl cyclohexane
7,7-Dichlorocarane
Thialdine
6-Chloro-8-chloromethyl-1,3-benzodioxane
6-t-Butyl-8-chlorobenzo-1,3-dioxane
4-Methyl-4-trichloromethyl cyclohexa-2,5-dienone
S-p-Xylylene thiuronium chloroacetate
Cyclopentyl bromide
Pentachlorophenyl glycerol carbonate
By-product of p-Chlorobenzenesulfinic acid preparation

Group B

p-Chlorophenoxymethyl morpholinoethyl ether
p-Nitrobenzyl β-chloroethyl ether
Pentachlorobenzyl 2-chloroethyl ether
p-Chlorophenyl mercaptoethyl chloride
2,3,5-Trichlorophenyl mercaptoethyl thiocyanate
p-t-Butylphenoxyethyl thiocyanate
p-Chlorophenyl mercaptoisopropyl thiocyanate
β-Chloroethyl nicotinate
β-Thiocyanoethyl nicotinate
β-Thiocyanoethyl thiocyanoacetate
Mercaptodiethyl bis (thiocyanoacetate)
Cyanomethyl chloroacetate
(p-Chlorophenoxyethyl) sulfide
bis (β-p-t-Butylphenoxyethyl) sulfide
p-Chlorophenoxyethyl 2-chloroethyl sulfide
p-Chlorophenoxyethyl 2-thiocyanoethyl sulfide
p,p'-Chlorodiphenyl mercaptoethane

Group C

bis-β-Thiocyanoethyl p-xylylene ether
3,4-Dichlorophenyl mercaptoethyl chloride
1-p-Chlorophenyl-2,3-dithiocyanopropyl sulfide
2-Thiocyanatomethyl-4-chlorophenyl-β-thiocyanatoethyl sulfide
p-Chlorophenyl β-thiocyanoethyl sulfide
Thiocyanoethyl thiocyanoacetate
Mercaptodiethyl bis (chloroacetate)

CONTROL OF THE CODLING MOTH AND OTHER ORCHARDS PESTS WITH RYANIA[1]

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The staff of the Fruit Insect Section at the Kentville laboratory has been working on the development of spray programs whereby natural control may be supplemented with chemical control (4). To date, reasonable success has been obtained in the control of such major orchard pests as the oystershell scale, *Lepidosaphes ulmi* (L.), and the European red mite, *Metatetranychus ulmi* (Koch), by using fungicides that are harmless, or comparatively so, to the predators and parasites of these pests (2,3). Some pests, e.g., the codling moth, *Carpocapsa pomonella* (L.), do not always respond as quickly to such treatment and in these cases a selective insecticide is required.

In 1952, Dr. D. W. Clancy (in litt.) of the Entomology Research Branch, Kearneysville, West Virginia, using ryania on a few small plots, found it was a selective insecticide giving good control of the codling moth and apparently being innocuous to many beneficial insects. In 1953 and 1954, plots were arranged in apple orchards in Nova Scotia to test ryania against the codling moth and other pests and to determine its influence on natural control, its compatibility with fungicides, and the timing and number of applications required to control the moth.

CONTROL OF THE CODLING MOTH

Against some pests, e.g., the European corn borer, *Pyrausta nubilalis* (Hbn.), activated ryania is much better than ryania alone (5). The Kentville experiments with activated ryania powder[4] and untreated powder[5] showed only slight differences in effects on most orchard pests and on beneficial insects and mites.

TABLE I

Codling moth injuries on mature apples (average percentages on the three varieties Delicious, Wagener, and King) treated with three or four cover sprays of ryania, 1953. Hale orchard, Starr's Point, N.S.

Insecticide x	*No. of sprays*	*No. of apples examined*	*Stings*	*Deep entries*	*Total*
Ryanexcel 96-3	3y	2359	7.5	0.5	8.0
	4	2928	7.2	0.2	7.4
Ryanicide 100	3	1783	10.1	1.0	11.0
	4	2979	10.6	1.1	11.7

x Applied as a concentrate (6X) spray with a blower-type orchard sprayer, Ryanexcel 96-3 at the average rate of 21.3 and Ryanicide 100 at 18.7 lb. per acre per application.

y Dates of applications: June 29 (2nd cover), July 6 (3rd cover), July 13 (4th cover), and July 20 (5th cover).

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[4]Ryanexcel 96-3, S. B. Penick & Company, New York, N. Y.; a synergized ryania powder containing 96% ryania, 3% n-propyl isome (di-n-propyl maleate isosafrole condensate), and 1% wetting agent.

[5]Ryanicide 100, S. B. Penick & Company; the powdered ryania alone, ground to pass 95% through a 100-mesh sieve.

A comparison of the activated ryania and the untreated ryania powder for codling moth control is given in Table I. In a five-acre block of apple orchard, two plots were sprayed, one with activated ryania and the other with untreated ryania. The control was only slightly in favour of the activated ryania.

Compatibility

Ryania was combined with the fungicides commonly used for apple scab control in Nova Scotia. Plots of one acre or more were treated with three cover sprays (2nd, 3rd, and 4th) applied with a conventional high-pressure orchard spray machine. The percentages of fruit injured by the codling moth at harvest time are given in Table II. None of the fungicides except bordeaux caused any lowering of the toxicity of ryania. The reduction in toxicity when used with bordeaux was probably too slight to rule out the combination; many orchardists used the combination in 1954 with apparently satisfactory results.

TABLE II

Codling moth injuries on mature Golden Russet apples (2000 or more apples examined where available) treated with various combinations of insecticides and fungicides, 1954. Miller orchard, Upper Dyke, N. S.

Fungicide	*Insecticide, amount per* 100 *gal. (three applications)**	*Average amount of insecticide per acre per application, lb.*	*Stings* %	*Deep entries* %	*Total* %
Glyodin	Ryania**, 6 lb.	19.4	10.9	0.1	11.0
Glyodin	Ryania, 4 lb.	11.4	16.8	0.2	17.0
Bordeaux	Ryania, 6 lb.	21.2	23.2	2.0	25.2
Captan	Ryania, 6 lb.	20.5	11.7	0.3	12.0
Ferbam	Ryania, 6 lb.	13.8	9.4	0.4	9.7
Glyodin	DDT (50%), 2 lb.	8.2	2.4	1.7	4.1
Glyodin-bord.	Lead arsenate, 3 lb.	9.2	38.8	11.7	50.5
Bordeaux	Ryania, 4 lb.	11.6	20.2	4.1	24.3
Check, none	Check, none	0	9.6	57.5	67.2

*Dates of applications: June 28-30 (2nd cover), July 6-7 (3rd cover), July 19-20 (4th cover).
**Ryanicide 100.

Timing and Number of Applications

In another block of orchard, one to three sprays of ryania were applied on different dates (Table III). Codling moth eggs began to hatch about the end of June, when the second cover spray was applied by growers in most orchards. The peak of hatching was reached about July 12 and had dropped to small numbers by the end of July. The small stings (diameter less than 1/10 inch) resulted from punctures of the skin by larvae that died before they could enter the fruit. Most of the large stings were made by larvae that entered the fruit before they were killed by the insecticide. Deep entries were those injuries caused by larvae that penetrated the fruit and presumably reached maturity.

The best results were obtained from three applications of ryania beginning when the first eggs hatched and repeated at about ten-day intervals. However, the moderately heavy infestation was controlled with two applications and even single applications gave reasonably good control. Possibly two applications of ryania are sufficient to give an economical and satisfactory control of moderate infestations of the codling moth. Table III suggests that timing of the applications is not a critical consideration since ryania apparently has a reasonably long residual action and is also capable of killing larvae that have entered the fruit several days before the application of the spray.

TABLE III

Codling moth injuries on mature Wagener apples sprayed with ryania[x] (1000 apples scored per plot), 1954. Miller orchard, Upper Dyke, N. S.

Dates of applications June 14	June 30	July 8	July 20	July 28	Stings per 1000 apples: Diam. 1/10 inch or less	Stings per 1000 apples: Diam. more than 1/10 inch	Deep entries %	Free from injury %
*					462	43	3.7	67.1
*	*				540	35	1.8	65.3
	*				183	55	5.7	79.4
	*	*			215	12	0.9	82.5
	*	*	*		174	4	0	86.8
		*	*	*	301	50	0.4	78.1
		*	*		166	40	0.3	84.0
		*			215	47	1.9	80.5

x Ryanicide 100 applied as dilute sprays at 6 lb. per 100 gallons.

Use in Commercial Orchards

Ryania was recommended for trial purposes to apple growers in Nova Scotia in 1954. Some growers made from one to three applications at the recommended strength of six pounds per 100 gallons. The few growers who applied three sprays obtained practically complete control of the codling moth; most growers applied two sprays and were highly successful; and even those who applied only one obtained very encouraging results (in Nova Scotia there is only one full generation of the codling moth per year). The records given in Tables IV, V, and VI were taken in commercial orchards.

TABLE IV

Numbers of phytophagous and predacious mites in ryania-sprayed commercial orchards (20) and non-insecticide commercial orchards (16) in the Annapolis Valley, N. S., 1954.

	Average number of mites per leaf: *Ryania*	Average number of mites per leaf: *No insecticide*
Phytophagous mites and eggs		
June	2.8	2.4
July	11.5	7.5
August	6.5	15.1
Predacious mites and eggs		
June	0.5	0.3
July	1.2	0.4
August	1.2	1.4

Phytophagous mites, mainly the European red mite, increased in numbers as the season advanced in both the ryania-treated orchards and the non-insecticide orchards but were present in both in the same relatively small numbers. This increase in phytophagous mites was followed by an increase in predacious mites, which were present in sufficient numbers by August to either reduce the phytophagous mite infestation or hold it in check.

TABLE V

Predacious arthropods collected on trays from jarred limbs in 20 commercial orchards sprayed with ryania and 16 with no insecticidal treatment, Annapolis Valley, N. S., 1954 (average numbers per tray).

Month	*Group*	*Ryania-sprayed orchards*	*Non-insecticide orchards*
June	Thrips	3.4	3.1
July		9.8	7.6
August		11.0	12.1
June	Mirids	5.6	15.8
July		4.5	11.4
August		2.6	8.0
June	Others	2.5	2.9
July		4.4	31.2
August		4.9	17.7
June	Total	11.6	21.8
July		18.7	50.1
August		18.5	37.8

TABLE VI

Average numbers of injuries by the codling moth per 100 apples in 24 commercial orchards sprayed with ryania and 19 with no insecticidal treatment in 1954 and in the same orchards in 1953 after treatment with various insecticides, Annapolis Valley, N. S.

		Average number of injuries per 100 apples	
Year	*Treatment*	*Stings*	*Deep entries*
1953	Various insecticides	10.4	9.0
1954	Ryania	2.2	0.7
1953	Various insecticides	3.4	8.6
1954	No insecticide	1.5	9.3

The records of predacious insects and spiders were obtained by jarring limbs on one-quarter sections of four trees and collecting the dislodged arthropods on a tray held under the limbs. The averages for the two groups of orchards show about the same number of thrips in the ryania-sprayed orchards as in the non-insecticide orchards. Mirids were fewer in the ryania-sprayed orchards but, as this was evident in June before ryania was applied, the difference cannot all be due to applications of ryania, although some species of mirids are known to be susceptible to ryania. In a few of the non-insecticide orchards *Anystis agilis* Banks was unusually abundant and this made the number of "others" exceptionally large in the non-insecticide group.

Use in Ontario and British Columbia

In Ontario, in an 1.8-acre block of bearing apple orchard, treated by the staff of the Entomology Laboratory at Vineland Station in 1954, ryania reduced codling moth injuries on McIntosh apples to 3.4 per cent stings and 3.2 per cent deep entries where there had been a very heavy infestation the previous year. Four of the six applications of ryania were used in combination with glyodin and all were applied with an automatic air-blast type of machine as a 5X concentrate at about 20 pounds of ryania per acre.

In British Columbia, in experiments conducted by the staff of the Entomology Laboratory at Summerland in 1954, ryania gave good control of the codling moth when applied by a low-volume, automatic concentrate spray machine; four applications each of about 48 pounds of ryania per acre were necessary to control the two generations. The ryania treatments allowed more stings and wormy apples than four DDT treatments each of 12 pounds per acre, wormy apples on Delicious trees averaging 0.1 per cent for DDT, 1.5 per cent for ryania, and 11.2 per cent for the check. In 1953, McIntosh trees sprayed with ryania at 15 pounds per acre in each of four applications — two for each generation — had 49 per cent wormy apples compared with 4.5 per cent on trees sprayed on the same dates with DDT (12 lb. of 50% DDT per acre per application) and 48.6 per cent on the check trees.

EFFECTS ON BENEFICIAL ARTHROPODS

Ryania was relatively innocuous to the beneficial insects, mites, and spiders. It had little or no effect on typhlodromids, the predacious mites that are often responsible for rapid reductions in European red mite infestations. Some of the most active predacious mirids, such as *Hyaliodes harti* Knight, were only slightly reduced in numbers by ryania sprays. *Criocoris saliens* (Reuter), one of two mirids (see the green apple bug below) rather susceptible to ryania, is predacious but is also suspected of stinging and injuring fruit. *Anthocoris musculus* (Say) and the predacious thrips *Haplothrips faurei* Hood and *Leptothrips mali* (Fitch) were only slightly reduced in numbers by ryania treatments of apple trees.

CONTROL OF OTHER ORCHARD PESTS

Ryania was much less toxic to most other orchard pests than to the codling moth. There was only about 50 per cent mortality of larvae of the eye-spotted bud moth, *Spilonota ocellana* (D. & S.), in Nova Scotia from a single application made when egg hatching was about complete (Table VII). Two and three applications, applied in commercial orchards for codling moth control, gave considerable control of the bud moth and infestations averaged lighter in these orchards than in orchards treated with DDT. Records of infestations of the white apple leafhopper, *Typhlocyba pomaria* McA., were taken in the codling moth plots where three cover sprays had been applied. Table VIII shows that the leafhoppers had been reduced to about one-half on July 9 after two applications of ryania; by September 7, over a month after the third and final application, the ryania plots were practically free from leafhoppers. In Ontario, ryania apparently gave good control of leafhoppers, mostly *T. pomaria* and *T. froggatti* Baker. In Nova Scotia, the activated ryania was somewhat more effective against the apple mealy bug, *Phenacoccus aceris* (Sign.), than ryania powder alone but both gave poor control. Ryania was

TABLE VII

Eye-spotted bud moth control with midsummer sprays of various insecticides applied when hatching was nearly complete (from record made two weeks after treatment), 1953.

Insecticide	*Amt. per* 100 *gal.*	*No. of leaves examined*	*No. of live larvae*	*Per cent reduction*
None		2895	438	0
Ryanexcel 96-3	6 lb.	1241	78	58.3
Ryanicide 100	6 lb.	1337	101	49.7
Malathion, 25%	2 lb.	1336	1	99.6
Parathion, 15%	¾ lb.	1203	6	96.7
Nicotine sulphate, 40%	1 pt.	684	16	84.7

TABLE VIII

Numbers of the white apple leafhopper collected by fumigating trees in midsummer and the numbers recorded per 1000 leaves examined on September 7, 1954, after treatment with several insecticides.*

Fungicide	*Amount of insecticide per* 100 *gal.*	*Collected by fumigation June* 21	*Collected by fumigation July* 9	*Recorded per* 1000 *leaves, Sept.* 7 (*adults and nymphs*)
Glyodin	Ryania, 6 lb.	481	211	7
Glyodin	Ryania, 4 lb.		235	5
Bordeaux	Ryania, 6 lb.	752	516	8
Captan	Ryania, 6 lb.		218	1
Ferbam	Ryania, 6 lb.		220	0
Glyodin	DDT (50%), 2 lb.			0
Glyodin-bordeaux	Lead arsenate, 3 lb.	599	478	349
Bordeaux	Ryania, 4 lb.		578	29
Check	None			415

*Insecticides applied June 28-30, 2nd cover spray; July 6-7, 3rd cover spray; July 19-20, 4th cover spray.

moderately toxic to the tent caterpillars *Malacosoma disstria* Hbn. and *M. americanum* (F.), but its action was slow. It had little if any effect on the European red mite and other mites, whether phytophagous or predacious, although some control of the clover mite, *Bryobia praetiosa* Koch, was obtained in British Columbia.

A heavy infestation of the apple maggot, *Rhagoletis pomonella* (Walsh), developed in the experimental block of orchard at Vineland Station, Ontario, that was sprayed with ryania during the period of fly activity; the ryania seemed to have no effect on the adults. At Morden, Manitoba, ryania sprays of four pounds per 100 gallons, applied by Mr. H. P. Richardson, Entomology Field Station, to hawthorn at weekly intervals from the time the first fly was observed until the fruit was ripe, failed to give any reduction in numbers of apple maggot larvae in the fruit. During this period flies were observed to be as numerous after spray applications as before and to mate on leaves and to oviposit in fruit heavily coated with ryania.

In British Columbia, ryania treatments for the codling moth kept the apple aphis, *Aphis pomi* Deg., and the woolly apple aphid, *Eriosoma lanigerum* (Hausm.), under control.

In Nova Scotia, the green apple bug, *Neolygus communis novascotiensis* Knight, was controlled by a single ryania spray applied when the nymphs were nearly half-grown.

DISCUSSION

The principal source of the botanical insecticide ryania is the dried, ground stems of the tropical plant *Ryania speciosa* Vahl., a shrub or small tree native to Trinidad, B.W.I., which belongs to the family Flacourtiaceae (1). For use as an insecticide, the stem wood (up to 3 inches in diameter) is ground to a powder, fine enough for 95 per cent to pass through a 100-mesh sieve. The active principle of ryania is the alkaloid ryanodine, which has approximately 700 times the insecticidal potency of the stem wood of *Ryania speciosa*. It is said to be more stable on exposure to light and air than pyrethrum or derris and less toxic than derris to mammals. On insects, ryanodine exerts a highly selective action on muscle tissue, causing a flaccid paralysis, thus rendering them incapable of normal activity.

In Nova Scotia, ryania gave effective control of the codling moth and interfered little with the biotic control of this moth and other orchard pests. Although ryania does not give satisfactory control of a number of other pests, e.g., the eye-spotted bud moth, the reduction it causes in their numbers may sometimes be sufficient to bring them to the point where a further significant reduction by their natural enemies may hold them in check.

Experiments have not been in progress long enough to furnish the necessary data on which to base an opinion of the long-term effects of ryania. However, a five-acre block of orchard sprayed with ryania for codling moth control in 1953 was purposely not treated for the codling moth in 1954, to see whether predators and parasites were present in sufficient numbers to hold the moth in check. The relatively small amount of codling moth injury in the orchard in 1954 (Table IX) indicates that natural control was very effective. This is in marked contrast to the sudden increase in injuries by the codling moth in 1951 following the equally good control from DDT in 1950.

DDT still gives good control of the codling moth in Nova Scotia: it has not been used extensively enough to favour development of resistant strains, but the serious infestations of the European red mite, the eye-spotted bud moth, and other pests that almost invariably follow applications of DDT have discouraged its use in Nova Scotian orchards. Investigations at the Kentville laboratory showed that the sudden increase in the populations of these pests was due to drastic reductions of their natural enemies (3,4). With the continued use of DDT for codling

TABLE IX

Codling moth injuries on Delicious apples in the Hale orchard, N.S., 1950-54.

		Codling moth injuries on mature fruit, %	
Year	*Insecticide*	*Stings*	*Deep entries*
1950	DDT	0.7	0.7
1951	None	4.8	37.7
1952	Lead arsenate	21.0	31.5
1953	Ryania	6.5	0.2
1954	None	0.4	1.4

moth control, other insecticides and miticides had to be used to control other pests. This increased the cost of spraying, left undesirable and often dangerous spray residues, and often reduced the quality of the fruit.

Ryania for codling moth control will probably cost more initially than some other control measures but, if it allows predators and parasites to become fully effective and additional control measures are not required for other pests, it should, in the end, be the cheapest and most lasting control for the codling moth and some of the other pests.

SUMMARY

In the control of the codling moth, ryania, a selective botanical insecticide, compared favourably with DDT and has not caused outbreaks of other pests by interfering with natural control, during the two years it has been under trial in Nova Scotia.

Though activated ryania (synergized with *n*-propyl isome) is much more toxic to some insects than the untreated ryania, with the codling moth and other orchard pests there were only slight differences.

Ryania was compatible with the fungicides glyodin, ferbam, and captan; with bordeaux, there was a slight, probably unimportant, reduction in toxicity.

In Nova Scotia, where usually there is only one generation per year, best control of the codling moth was obtained from three applications of ryania beginning when the first eggs hatched and repeated at seven- to ten-day intervals. However, good control was obtained with two applications in many commercial orchards. Similar results were obtained in Ontario but it was necessary to make six applications during the season. In British Columbia, four applications were necessary to control the two generations of the moth and the amount of ryania required per acre was more than double that used in Nova Scotia and Ontario.

ACKNOWLEDGMENTS

Acknowledgments are made to Mr. A. D. Pickett, Officer-in-Charge, Fruit Insect Section, Kentville, for direction of and assistance in the investigations; to Mr. W. G. Garlick, Entomology Laboratory, Vineland Station, Ont., for records and notes on ryania investigations in Ontario; to Mr. C.V.G. Morgan, Entomology Laboratory, Summerland, B.C., for records and notes on ryania investigations in British Columbia; to Mr. H. P. Richardson, Entomology Field Station, Morden, Manitoba, for information on apple maggot control; and to Mr. A. W. MacPhee and other officers of the Kentville Laboratory for notes on the effects of ryania on beneficial arthropods.

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ANATOMY AND HISTOLOGY OF THE DIGESTIVE TRACT OF THE LARVA OF THE SAWFLY *Pteronidea ventralis* Say (HYMENOPTERA : TENTHREDINIDAE)

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MATERIAL AND METHODS

The insects used in this study were last-instar larvae of the sawfly *Pteronidea ventralis* Say, averaging about 13 mm. in length, taken from a willow shrub growing on a clay bank on the beach of Lake Erie in the extreme south-west corner of Dunn Township, Haldimand County, Ontario, on July 30, 1950. Several dozen specimens were collected. Some of these were stored in 70% alcohol for use in studying the gross anatomy of the digestive tract. For examining the dorsal aspect of the tract the integument of a specimen was slit, with fine scissors, along its mid-dorsal line from the anus to the back of the head. It was placed on a layer of wax in a watch glass and covered with water and the integument was pinned flat to the wax with insect pins,

thus disclosing the whole length of the digestive tract. The ventral aspect was studied in similar fashion, the mid-ventral line of the body, in this case, being slit with scissors and the specimen laid on its back and the integument pinned flat. Live specimens to be used in histological studies were killed in a poison jar and immediately after death their integument was slit along the mid-dorsal line and they were put in Bouin's fixative for about 12 hours. Serial longitudinal and transverse sections, cut at 10 microns, were made of the whole insects and the sections were stained with Delafield's haematoxylin and eosin. In the following account the terms applied to the features of the digestive tract are those used by Snodgrass (1935).

DESCRIPTION

The anatomical features of the digestive tract, in dorsal and ventral aspect, are shown in Figures 1 and 2. The tract is a straight tube extending from the head, through the three thoracic and ten abdominal segments, to the anus. The stomodeal portion of the tract is the oesophagus (O), about 1 mm. long, extending from inside the head to the stomodeal valve (SV). Surrounding the oesophagus are spherical lobes of the accessory glands (AG) of the silk-producing apparatus. The silk glands (SG) are two long, convoluted tubes, one lying on each side of the mid-ventral line of the digestive tract. They extend the full length of the mid-gut and are applied closely to its surface and are embedded throughout their length in the tissues of the fat-bodies (FB). The bulk of the digestive tract is composed of the mid-gut (MG), a cylindrical tube about 1.5 mm. in diameter, extending from the second thoracic to the eighth abdominal segment. At the posterior limit of the mid-gut is the pyloric valve (PV) surrounded externally by the bases of the Malpighian tubules (MT) which are about thirty in number. Each Malpighian tubule extends forward along the mid-gut for about 2 mm. and then loops backward and extends past the pyloric valve and along the proctodaeum to the rectal sac (RS). The anterior intestine (AI) of the proctodaeum is, at its anterior end, of the same diameter as the mid-gut and narrows posteriorly towards the rectal valve (RV). The rectal sac (RS) of the posterior intestine occupies the posterior end of the abdominal cavity. In its gross features the digestive tract of *Pteronidea ventralis* resembles that of caterpillars as described by several authors (e.g. Peterson, 1912), for in a caterpillar there is the short oesophagus, large mid-gut and strong rectal valve and the ends of the Malpighian tubules are embedded in the proctodaeum. Accessory glands are also associated with the silk glands of caterpillars (Imms, 1948).

The oesophagus (Fig. 3, 4 — O) leaves the head through the foramen magnum (FM) and is about 0.3 mm. in diameter. Just below it, in the cavity of the head, is the salivarium (Fig. 4 — SVM) of the silk-producing apparatus. The two ducts of the silk glands (SG) converge on the posterior end of the salivarium and each of these ducts receives another duct from the accessory gland (AG). The tissues of the lining of the oesophagus are thrown up into several irregular folds running along the length of the organ (Fig. 5). The intima lining the oesophagus consists of the ectocuticle (ECC) with an irregularly roughened surface and the endocuticle (ENC) about twice as thick as the ectocuticle. In the larva of a sawfly of the genus *Lophyrus* the lining of the oesophagus also shows irregular folds and roughened ectocuticle (Saint-Hilaire, 1931). The epithelium (EP) is a simple cuboidal epithelium with large oval nuclei in the cells. In the cavities of the longitudinal folds are strands of longitudinal muscle (LM). The outer layer of the oesophagus is composed of circular muscle (CM) two or three strands thick.

The stomodeal valve (Fig. 3 — SV), (Fig. 6) is formed by the extension of the end of the oesophagus into the anterior end of the mid-gut. The stomodeal tissues, lined with cuticle (CU), extend into the lumen of the mid-gut (MG) in the form of several irregular lobes. The circular muscle (CM) extends well down into these lobes while the longitudinal muscle (LM) diverges from the circular muscle and extends obliquely across the width of the stomodeal valve and passes down the length of the mid-gut to form the outer layer of that structure. The other tissues of the mid-gut, adjacent to the stomodeal valve, are the epithelial layer of large cuboidal cells (EP) with large oval nuclei and heavily striated borders (SB), and the strands of circular muscle (CM) partially embedded in the outer ends of the epithelial cells.

The mid-gut (Fig. 3 — MG), (Fig. 7) is circular in transverse section. Its lining is an epithelial layer (EP), composed of cuboidal cells, about 0.1 mm. thick. Each cell bears a striated border (SB), about half the width of the rest of the cell, extending into the lumen of the mid-gut. Newcomer (1914) in studying the digestive epithelium of the silkworm and other insects described this border as an "intima with pore canals". Newell and Baxter (1937), however, showed that the striated border consists in many cases of separate filaments extending from the free border of the cells. In their study of mid-gut epithelia they distinguished between motile cilia as found in some worms and non-motile extensions of the protoplasm, including "rod-borders" as found in earthworms and "brush-borders" as found in insects. The striated borders of the cells in *P. ventralis* are in this latter category of "brush-borders", described also as "striated hems" by Imms (1948). Beneath the epithelium of the mid-gut is the circular muscle (CM), consisting of one narrow strand, and outside this are the strands of longitudinal muscle (LM), approximately equally spaced from one another around the circumference of the mid-gut. The peritrophic membrane (PM) lies in the lumen of the mid-gut adjacent to, but free from, the epithelial layer. It consists of several concentric sheets and thus is evidently of the "lamellar" type produced by secretion from the epithelial cells, as described by Wigglesworth (1950).

The pyloric valve (Fig. 3 — PV), (Fig. 8) lies at the end of the mid-gut and leads into the anterior intestine (AI) of the proctodaeum. Its position is marked by the Malpighian tubules (MT) which surround it externally and empty into it. Anterior to the openings of the tubules the tissues are those of the mid-gut, there being an inner layer of epithelial cells (EP) showing striated borders and a layer of circular muscle (CM) surrounded by strands of longitudinal muscle (LM). Posterior to the openings of the tubules, in the anterior intestine (AI) of the proctodeum, the epithelial layer (EP) secretes a cuticle (CU) and the circular muscles (CM) lie outside the longitudinal muscle (LM). The anterior intestine narrows abruptly to form the rectal valve (Fig. 3 — RV), (Fig. 9). This valve is surrounded by heavy circular muscle (CM) several strands in thickness. Some strands of transverse muscle (TM) traverse obliquely the width of the circular muscle. A few strands of longitudinal muscle (LM) extend backward along the anterior end of the rectal sac (RS). The lining of the valve consists of a cuticular intima which is closely beset with flat spines (Fig. 9, 10 — SP). These spines project backward and each is armed along its posterior border by several small, sharp, irregular teeth. The most heavily sclerotized spines are those toward the anterior end of the valve.

The rectal sac (Fig. 3, 9 — RS), (Fig. 11) of the posterior intestine widens out abruptly from the end of the rectal valve and is a cylindrical structure about 2 mm. long. Its cuticular lining (Fig. 11 — CU), secreted by the epithelium (EP), is thin. Outside the epithelium are the Malpighian tubules (MT) encircling the circumference of the rectal sac. The tubules are held in place against the epithelium by a sheet of thin connective tissue (CT). The posterior end of the digestive tract is the rectum (Fig. 3 — R), (Fig. 12) leading to the anus (Fig. 3 — A). The rectum is dorsoventrally flattened (Fig. 12) and surrounded externally by strong circular muscle (CM). Strands of transverse muscle (TM) traverse the circular muscle and continue beyond the limits of the rectum to their attachment on the adjacent integument of the body wall of the tenth abdominal segment (Fig. 3). Internally the rectum has several longitudinal ridges which are irregular in transverse section and armed with heavy cuticle (CU). Beneath the cuticle is the epithelium (EP) consisting of cuboidal or columnar cells.

The Malpighian tubules (Fig. 1, 3, 8 — MT) arise from the periphery of the pyloric valve. The epithelial layer of each tubule has a striated border and contains spherical nuclei (Fig. 8). Each tubule extends forward along the mid-gut and then loops backward along the mid-gut and anterior intestine to the rectal sac where its free end is bound to the side of the rectal sac by the envelope of connective tissue (Fig. 11 — CT). The association of the free ends of Malpighian tubules with the proctodaeum has been noted by several authors. Ramdohr (1811) and Gorka (1914) described this association occurring in insects in several orders. Dufour (1840, 1843) and Sirodot (1858) pointed out that the insertion of the tubules into the proctodaeum is superficial and that the lumen of the individual tubule does not open into the proctodaeum. Woods (1916) shows that the ends of the six tubules of the larva of the beetle *Haltica bimarginata*

are embedded in the outside of the colon in a "peritoneal envelope" comparable to the envelope of connective tissue surrounding the tubules in *Pteronidea ventralis* as described by the present writer. In the majority of lepidopterous larvae the tubules penetrate the wall of the rectum in such a way that they are arranged in two rows, an inner and an outer row, around the circumference of the rectum (Ishimori, 1924; Poll, 1938). Poll (1937) also describes the penetration of the tubules into the proctodaeum of sawfly larvae.

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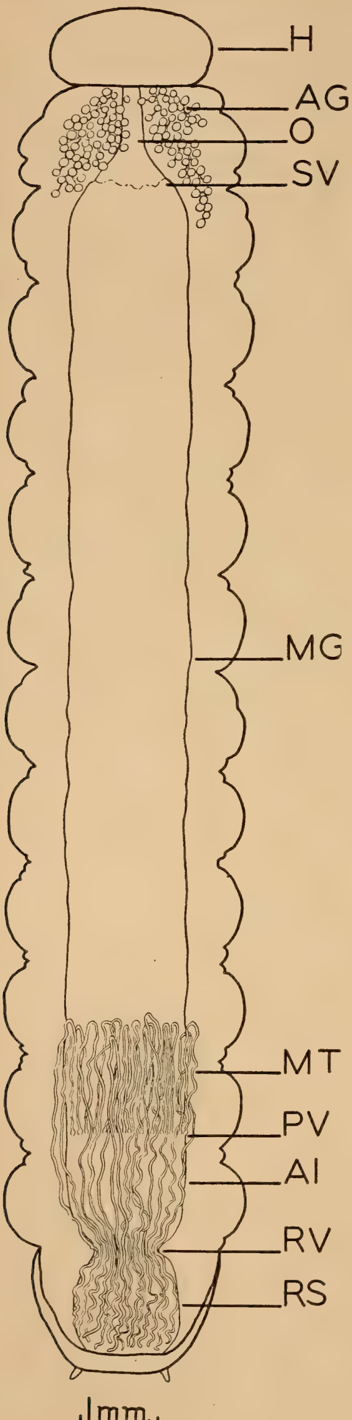
Fig. 1.



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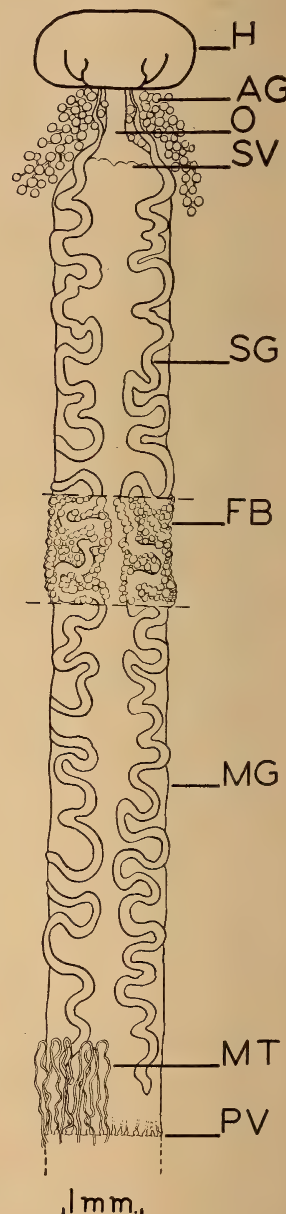

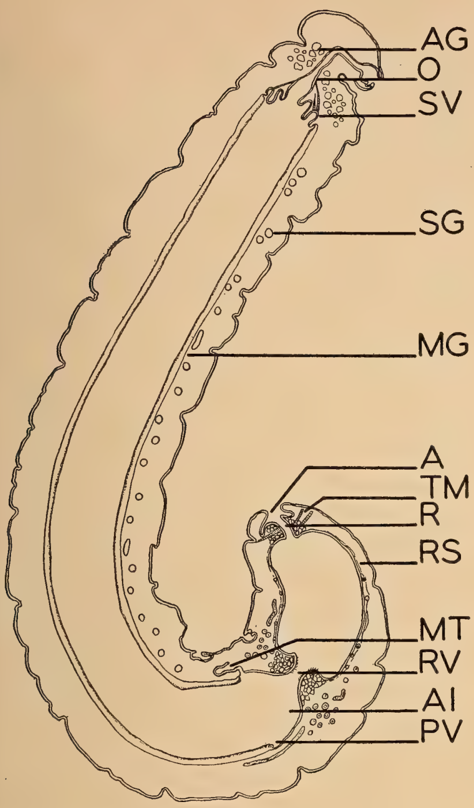

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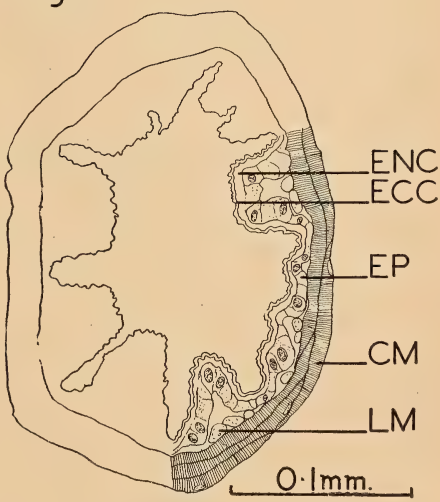
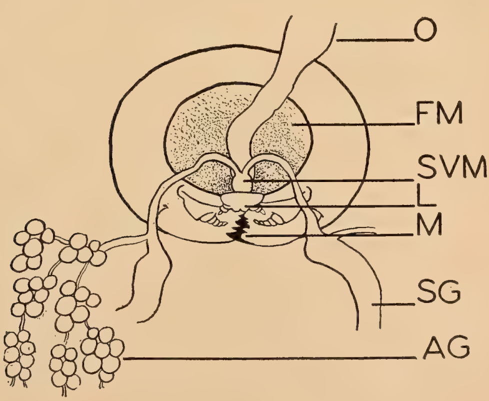




1mm. Fig. 4.

Fig.6.

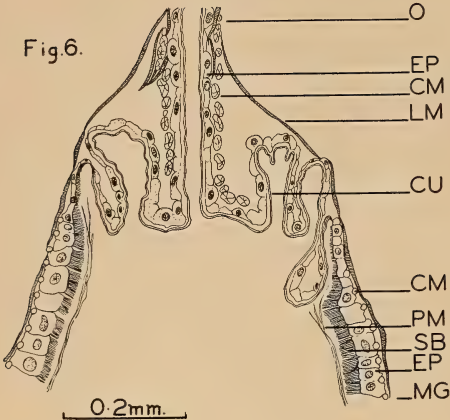
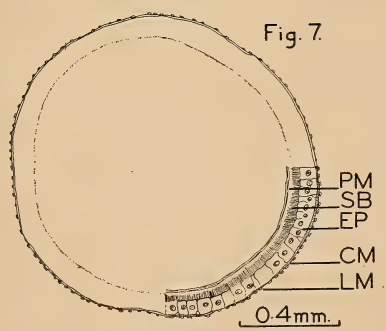


Fig.8.

Fig. 7.



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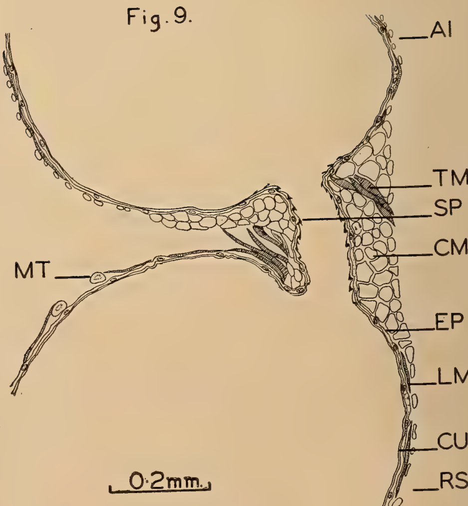

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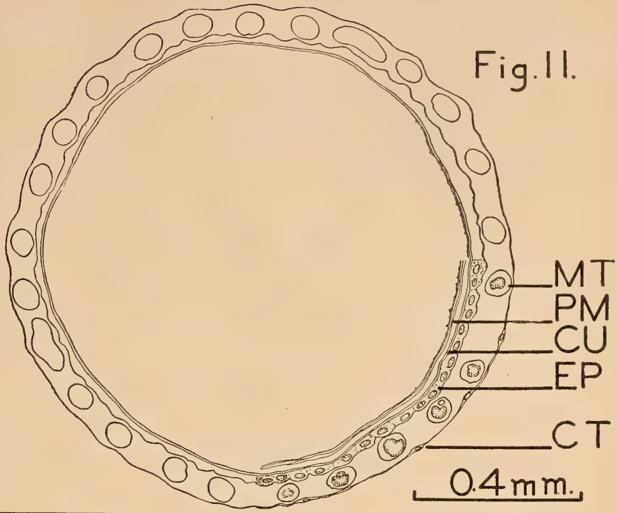

Fig. 11.

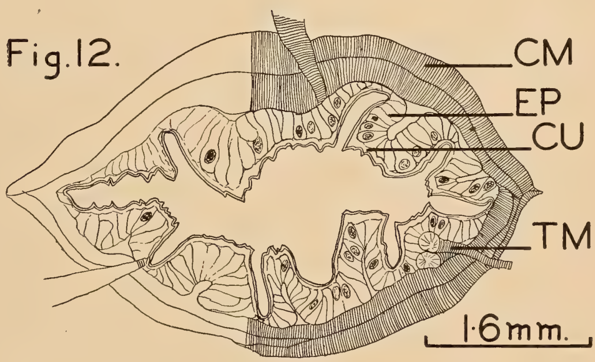

Fig. 12.

LEGEND FOR FIGURES

Fig. 1 — Dorsal view of digestive tract
Fig. 2 — Ventral view of digestive tract
Fig. 3 — Sagittal section of digestive tract
Fig. 4 — Posterior view of head showing oesophagus and silk-producing apparatus
Fig. 5 — Transverse section of oesophagus
Fig. 6 — Longitudinal section of stomodeal valve
Fig. 7 — Transverse section of mid-gut
Fig. 8 — Longitudinal section of pyloric valve
Fig. 9 — Longitudinal section of rectal valve
Fig. 10 — Portion of intima of rectal valve
Fig. 11 — Transverse section of rectal sac
Fig. 12 — Transverse section of rectum

A — anus
AG — accessory gland
AI — anterior intestine
CM — circular muscle
CT — connective tissue
CU — cuticle
ECC — ectocuticle
ENC — endocuticle
EP — epithelium
FB — fat body
FM — foramen magnum
H — head
L — labium
LM — longitudinal muscle
M — mandible
MG — mid-gut
MT — Malpighian tubule
O — oesophagus
PM — peritrophic membrane
PV — pyloric valve
R — rectum
RS — rectal sac
RV — rectal valve
SB — striated border
SG — silk gland
SP — spine
SV — stomodeal valve
SVM — salivarium
TM — transverse muscle

CONTROL OF THE PEA APHID WITH MALATHION IN NOVA SCOTIA[1]

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In recent years DDT has been favoured to some extent for controlling the pea aphid, *Macrosiphum pisi* (Kltb.), on canning peas grown in the Annapolis Valley. Since pea vines treated with DDT should not be fed to livestock, insecticides that have shorter residual toxicity and therefore are not as hazardous to livestock are now preferred.

In July and August, 1954, a field experiment was conducted on a farm at Welsford, N. S., to determine, under local conditions, (a) the value of 50 per cent malathion spray concentrate and 4 per cent malathion dust[3] in controlling the pea aphid, (b) the amount of toxic residue of malathion on the vines, and (c) the effects of the two formulations on the quality of the peas.

METHODS

The experimental fields subjected to spraying and dusting contained four and six acres and were sown to Perfection and Pride peas respectively. The sprayed field was west of that to be dusted to avoid drift of dust that might be caused by the prevailing westerly winds. A check area of one-half acre was left untreated between the two.

To estimate the aphid populations and the effectiveness of the treatments, the vines were swept with a standard insect net (15 half-circle sweeps per treatment) twice weekly from July 7 to August 18 and the collected insects counted. In this way it was determined that the aphids were numerous enough to warrant control measures on July 19, when an average of 26 aphids per sweep were collected; accordingly spraying was done on this date; owing to unfavourable weather dusting was delayed until July 22.

The spray was applied with a truck-mounted Hardie sprayer having a 30-foot boom with 54 nozzles at the rate of 24 fluid ounces of 50 per cent malathion emulsifiable spray concentrate in 75 gallons of water per acre. The 4 per cent malathion dust was applied with a tractor-drawn Niagara duster at 35 pounds per acre.

RESULTS AND DISCUSSION

Sampling the aphid population by sweeping showed that the malathion spray reached its maximum effect three days after application, when an average of one aphid per sweep was collected; the population then increased gradually. In contrast, malathion dust was most effective one day after application, when an average of 0.3 aphids per sweep were collected, and

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[3]Both formulations supplied by Green Cross Products, Montreal, Que. The emulsifiable spray concentrate contained 5.2 pounds of malathion per Imperial gallon.

continued to cause great reduction in population for almost a week longer than the spray. Although dusting gave superior reduction in population, the disadvantages of this method of applying insecticides in Nova Scotia, where unfavourable winds are frequent, will restrict its use.

The aphid population did not increase greatly in either the sprayed or the dusted field at any time between the application of malathion and the harvesting of the peas in late August. Random population sampling showed that in no case were more than an average of four aphids per sweep collected after August 2. This number is considered by experienced fieldmen and growers to be well below the danger level at this point in the growing season, that is, within one month of harvest. These results were supported by the fact that in the same season malathion was fairly widely used as a spray in canning pea fields in the Annapolis Valley and without exception gave satisfactory control of the pea aphid.

Random samples of pea vines were taken from the sprayed and dusted areas 15 and 13 days respectively after application and analysed for toxic residues. No residue of malathion was found by an analytical method sensitive to 0.8 p.p.m. (2), confirming previous observations that malathion residues on plants are rapidly lost (1).

Random samples of peas taken from the experimental plots were tested for tenderness shortly after harvesting and taste tests were conducted on the canned peas in January, 1955. No difference was found that could be attributed to the treatments.

Since malathion gives control equivalent to that from DDT, leaves no excess of toxic residues, and is reasonably safe to apply, it is preferable to DDT, which may leave an excessive and long-lasting amount of poison on the foliage.

SUMMARY

In Nova Scotia, excellent control of the pea aphid on canning peas was obtained with a spray containing 24 fluid ounces of 50 per cent malathion emulsifiable concentrate or with 35 pounds of 4 per cent malathion dust per acre. The dust was superior in initial mortality and duration of effectiveness. Chemical analysis of the vines 13 and 15 days after application showed no residue of malathion. No difference in tenderness or taste of the canned peas attributable to the insecticide was detected.

ACKNOWLEDGMENTS

Thanks are extended to Mr. A. Benjamin, Welsford, for providing the land on which the experiment was run, and to Mr. A. Smith, Senior Fieldman, Graves Canning Company, Berwick, for practical guidance and assistance.

The co-operation of Messrs. D. Chisholm and G. W. Hope of the Canada Department of Agriculture, Kentville, N. S., who undertook chemical and quality analyses respectively, is gratefully acknowledged.

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THE BIOLOGY OF THE ADULTS OF *HYLEMYA BRASSICAE* (BOUCHÉ) (DIPTERA: ANTHOMYIIDAE)[1]

W. H. Foott[2]

A study of the cabbage maggot has been under way for many years in Canada, Britain, and the United States of America. The majority of the work in this problem has been concerned with the immature forms and their control. Very little attention has been paid to the biology of the adult *H. brassicae*.

The adults of the cabbage maggot are difficult to distinguish from those of several other species of flies. Consequently, accurate observations in the field were difficult, and the majority of this work had to be conducted in the laboratory and insectary. Because of the relatively short time allotted for such a project, and the lack of a suitable infestation in 1952, the results in several instances were based on a small number of observations.

In this paper the description follows, in a more or less chronological order, the activities of the flies from the time of emergence until their death.

MATERIALS AND METHODS

This study of the biology of the cabbage maggot adult was based partly on observations in the field, but more on experiments in the laboratory, insectary, and greenhouse.

Several thousand pupae were obtained each year from root cellars, infested turnip fields, and by rearing. These afforded an opportunity to observe the various aspects of the biology of the adults which emerged. The pupae were kept in glass jars, and the flies, upon emergence, were transferred to rearing cages. The rearing cages, which were modelled after a type used at the Belleville Parasite Laboratory, were 11 inches wide, 16 inches high, and 11 inches deep. The bottom was solid, the front composed of a sliding lucite door, and the top, back, and two sides made of a good grade of cheesecloth. A circular hole 1¾ inches in diameter in the centre of the lucite door and fitted with a cork was found to provide a suitable method for introducing insects into the cage. Food was supplied by means of a wick of dental cotton projecting from a vial, the cotton being soaked with the desired food solution.

The fields visited to study the insect in its natural habitat were all turnip fields. In 1951 there were only three fields which were visited frequently. One was at the Ontario Agricultural College, another was at Puslinch (11 mi. S.E. of Guelph), and the third was at Mill Grove (21 mi. S.E. of Guelph). In 1952 eight fields at Exeter (Huron county) and nine at Bright (Oxford county) were visited bi-weekly. Most of the field observations were made at the Oakes farm near Salem (15 mi. N.W. of Guelph).

PUPAE AND EMERGENCE OF THE ADULTS

The pupae were found usually within four or five inches of the roots of the plants, and at an average depth of from two to four inches.

The pupae can withstand many adverse conditions and still produce normal, healthy flies. The complete pupal cases were removed from almost fully developed flies and the nearly mature flies placed in soil. Several normal adults emerged from this soil a few days later. Pupae were placed in vials of water for a given period of time, removed, and placed in soil. Several pupae which had been in water for as long as twenty days produced adults. An acid solution composed

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of 14.7 cc. of 95% chemically pure sulphuric acid and 78.7 cc. of distilled water was accidently spilled into a bottle containing one hundred pupae. Sixty-four of these produced flies or parasites. Desiccation had little effect on emergence under insectary conditions. Ten pupae were placed in a culture dish without any soil and left in the open area of the insectary, where they were exposed to the summer sun for several hours each day. Five flies emerged, three after an exposure of 22 days. Humidity also had little effect on emergence. In one experiment one hundred pupae were placed in a glass jar, where the relative humidity was low, and another hundred were kept in a R.H. of 80%. The emergence was 90% and 89% respectively.

Adults emerge from overwintering puparia in the spring. The spring generation of flies in the Guelph area in 1952 started to emerge during the first two weeks of May. Cages had been placed over parts of a field which was infested in 1951. The first fly was captured on May 2. Pupae obtained from an outside turnip pit began to produce adults on May 12. Emergence from pupae obtained in a turnip root cellar, which had been damp and cool, began on May 24. Under laboratory and insectary conditions most of the flies emerged in the morning between 8:00 a.m. and 11:00 a.m.

The fly, when it was ready to emerge, pressed against the anterior end of the pupal case. It was possible to see the puparium move slightly while the fly was endeavouring to break out. The pressure of the distended ptilinum ruptured the anterior end of the puparium and the sound produced could often be heard for a short distance. A circular split was formed about 1 mm. from the anterior end and also a vertical split which joined the circular split on two sides. The vertical split divided the cap into two approximately equal pieces. The distended ptilinum appeared and was alternately collapsed and distended as the fly strained to free itself of the puparium. The average time required for emergence of ten flies observed was three minutes.

The emerged fly was soft and light coloured, and had crumpled damp wings. The ptilinum continued to expand and contract. Newly emerged flies were placed in a narrow vial of soil and the method by which they move through the soil observed. The fly thrust its head forward and distended its ptilinum. The ptilinum was then contracted and the body drawn into the small space created in the soil. This procedure was repeated until the fly had reached the surface. The time required for freshly emerged flies to reach the surface through two inches of soil varied considerably under laboratory conditions. Observation of emerging flies in narrow vials of soil showed that some flies went directly to the surface whereas others often moved upward a short distance, then horizontally, then upward again. Some actually went downward a short distance. Some flies came to the side of the vial but soon returned to the soil rather than crawl upwards between the side of the vial and the soil. This indicates that negative geotropism not light influences their approach to the surface. Some of the above observations suggest that the geotropic effect was weak. This was confirmed by placing emerging flies in a vial of soil and allowing them to move in an upward direction for approximately two inches and then reversing the tube. The flies continued toward the exposed soil surface for at least 1 to 1½ inches before reversing to an upward direction of travel. It seems possible that some flies move a considerable distance through the soil before reaching the surface. Flies with expanded wings and completely retracted ptilinum were unable to reach the surface from a depth of over two inches.

Entomologists have disagreed with respect to the number of inches of soil through which *H. brassicae* adults may emerge. Washburn (13) believed that they were unable to penetrate through six inches of soil under conditions as nearly like outside conditions as possible. Schoene (9) found that they could emerge from twelve inches under laboratory conditions. Other figures intermediate to the above depths may be found in the literature. The author placed pupae in soil in a long container and buried it in soil outside so that the pupae would be at the depth desired. The only suitable container that was available was closed at the bottom and prevented drainage of excess moisture. To offset this disadvantage a lid was placed over the top during very heavy rains. The depths tested ranged from 6 to 16 inches and flies emerged from every depth. The wings of the newly emerged flies unfolded gradually and required an

average of 22 minutes. The unfolded wings were light in colour and slightly convex. The flies then began to stroke the upper and lower surfaces of the wings with their hind legs. This might have served to dry the wings, or perhaps it was a cleaning habit. The "ovipositor" of each female was partly extended during this period. Flies sometimes emerged with damaged hind legs and in nearly every such instance the wings failed to expand. The author injured, and in some cases severed, the hind legs at the distal end of the femur of a number of flies immediately after emergence. This was repeated with the front and middle legs of other flies. When the hind legs were injured or severed the wings usually failed to expand, but normal wings developed if the front legs were injured, and, except for one fly, if the middle legs were injured. This experiment suggested that functional hind legs may be necessary for the expansion of the wings in most of these flies.

The wings soon lost their soft, opaque appearance, becoming firm and straight. The body and legs gradually assumed a darker colour. Glider-like movements from the top of a bottle to the table were usually possible 1¼ hours after emergence. The average time before they were able to fly more than a few feet was approximately two hours.

The flies were sexed before they were placed in a rearing cage. The sex ratio, which was based on a total of 4,910 flies, was approximately 1:1. Similar results have been recorded by other investigators but their samples have been considerably smaller.

The females apparently required several days longer than the males to develop. Males predominated for the first few days, then the ratio became approximately equal, and in the final period of emergence from any given group of pupae the females were in the majority.

The adults were strongly positively phototropic to all levels of light tested; they seldom left the side of a rearing cage which was directed toward a source of light. When a glass jar containing adults was held with the open end toward a window they immediately flew to it and remained there, but newly emerged flies often were not attracted as much to the light source. An experiment was conducted in a dark room to determine if newly emerged flies were negatively phototropic until their wings became functional. Lights were arranged on a table so that one side was more intensely illuminated than the other. Newly emerged and older flies were placed at the centre of the table, the wings of the older flies having been clipped. The flies, without exception, proceeded to the side which had the strongest illumination. The lights were then turned out and a desk lamp held over a small area of the table. The flies approached the small, lighted area, and could be attracted to any part of the table by moving the light. Newly emerged flies hesitated frequently in their advance toward the light and their path was quite erratic, but older flies responded much more quickly and directly. Although the adults appeared to be positively phototropic at the time of emergence, this response increased until they were able to fly.

FOOD AND FEEDING HABITS

Some workers have observed the flies feeding on nectar. Schoene (9) fed them on various substances such as bananas, sugar solutions, and blossoms. Vodinskaya (12) found that the flies fed upon the bloom of fruit trees in Russia, and that they, under artificial conditions, fed upon nectar of plants of the families Umbelliferae, Cruciferae, and Compositae. Brittain (1) found them on flowers but believed that they were feeding on the pollen.

The longest period that the author was able to keep a fly alive without food was three days, a figure which agrees quite closely with that found by previous investigators. Flies were never observed copulating before they had fed at least once.

Several groups of flies were fed a 39% sugar solution that approximated nectar, namely, 13% sucrose, 13% fructose, and 13% dextrose. The average life of the females fed on this diet was only 5.7 days, of the males 6.6 days, and no eggs were laid. When water was supplied as well as the nectar-like solution the average life of the females was 33 days, of the males 22 days, and 206 eggs were laid. A 5—7% sucrose solution also increased the length of life and many eggs were laid.

The above data suggest that water is just as important in the diet of the flies as nectar. Previously this appears to have been appreciated only by Caesar (4). Others have thought the flies were partaking of moisture but apparently have not considered it to be an essential part of their diet. Brittain (1) and Schoene (9) observed the flies lapping up water from moist soil.

To obtain additional information an experiment was conducted in the laboratory to determine their food preference. Tap water, 40% sucrose solution, 5% sucrose solution, and the 39% sugar solution were used in each test. Tap water was used as the solvent in the sugar solutions. Dental cotton wicks projecting from small vials were kept saturated with these four liquids and placed side by side in a rearing cage. The cage was placed in such a position that light was distributed evenly over the side along which the vials were located to avoid phototropic influence. The vials were left in one position for 24 hours, then rotated to another position every 24 hours until each vial had been in the four possible locations, thus eliminating any preference for one solution due to its position. Forty flies were used and the number of flies on each wick recorded at least once an hour during daylight. The results are shown in Table I.

TABLE I

FOOD PREFERENCES

	Total number of fly-visits to each wick during a 24-hour period.				
Food supplied	*Pos. 1*	*Pos. 2*	*Pos. 3*	*Pos. 4*	*Total of all four positions*
Tap water	29	61	96	62	248
40% sucrose solution	9	16	42	11	78
5% sucrose solution	16	23	67	41	147
39% sugar solution (approx. nectar)	8	4	28	7	47

The data in Table I show that when given a choice of food, the majority of the flies prefer tap water to sugar solutions.

Cabbage maggot flies were not observed feeding on the nectar of flowering trees or plants, nor were they captured in sweeps made around blossoms, but other entomologists have shown that nectar does form a part of their diet. The present work suggests that water is also an important item in the diet of these flies.

In the late summer and fall, when there are few sources of nectar available, do the flies subsist on water only, and if so, how long can they live, and are they able to oviposit? An answer was obtained to these questions by placing five each of recently emerged males and females in a rearing cage and providing them with tap water only. A slice of turnip in the cage provided a suitable site for oviposition. The results were as follows:

Average length of life of the males	8 days
Average length of life of the females	10 days
Total number of eggs deposited	241

A similar experiment was repeated at a later date with the following results:

Average length of life of the males	5 days
Average length of life of the females	11 days
Total number of eggs deposited	56

These experiments showed that water alone provided adequate sustenance for copulation and oviposition.

In the spring and summer the flies probably feed upon both nectar and water and live for at least three to four weeks, provided that other environmental conditions are satisfactory. In the late summer and early fall, when few sources of carbohydrates are available, they would feed upon water and live for a period of one or two weeks.

The flies in the laboratory and insectary fed more often in hot weather, and consequently may do so in the field. When the weather was cool very few flies were seen feeding on dental cotton wicks soaked in water or a sugar solution. One very hot day the wick was allowed to dry out, removed from the cage, resoaked with a 7% sucrose solution, and returned. Within less than a minute after the return of the cotton, 100 of the approximately 350 flies came down from the top of the cage to feed, and within two to three minutes more than one-half of them were feeding.

The flies frequently gorged themselves upon the sugar solution on hot days. Their abdomens distended to almost twice normal size; activity was greatly decreased. One female and one male fly, which had become gorged in this manner, were placed in a cage without food or water. The male lived four days and the female five days on the stored food.

The replete flies stood motionless on the side of the cage or on the cotton wick and regurgitated food as large drops of fluid. In some instances such drops were regurgitated and re-ingested at intervals of a minute or less, in others re-ingestion was delayed a half-hour or more. Frequently the drops were not reabsorbed but were deposited on the interior surfaces of the cage. The mortality of a group of replete flies was several times greater than that of flies with normal appearing or slightly distended abdomens.

ATTRACTION TO TURNIP FIELDS

The flies emerge and feed as soon as possible. Then it is assumed that they are attracted to a field of cruciferous plants, where they copulate and oviposit around the stems of the plants. No confirmation was obtained to show that turnips serve as a strong attrahent.

In rearing experiments a turnip or a slice of turnip was placed in a cage to provide a suitable site for oviposition. The flies seldom flew directly from the top or side of the cage to the turnip. When they were in any part of the cage other than on the turnip the flies were easily disturbed. A slight touch of a camel hair brush caused them to fly elsewhere in the cage. When they were on the turnip a fairly vigorous stroke with the brush often failed to dislodge them. These results possibly indicate that although the flies are not attracted to turnips they will remain near the turnips once they have reached them.

In another experiment a group of flies was placed in a rearing cage which was attached to another cage containing a turnip. The cages were joined with a short tube of clear plastic so that the flies need not enter a darker area to reach the turnip. Light intensity was identical for the two cages and each was supplied with a 5% sucrose solution. The cages were left in position for 24 hours. Males, infertile females, and fertile females were used in separate tests. Very few flies entered the attrahent cage in any test.

It was suggested to the writer that after a short time the turnip odour would permeate the area around the cages, thus reducing the gradient to such a point that flies were not attracted. Experiments were then performed with a modified Hoskins and Craig (6) olfactometer. The attrahent used was pieces of a leaf, stem, and root of a turnip plant. Three groups of flies were used in separate tests, namely, males, infertile females, and fertile females. The same insects were used only once in any day. They were left in the olfactometer for either a half-hour or one hour, and a record made every two minutes of the number of flies in the attrahent and check funnels.

The results in general were not very significant. In two tests with males there were more in the check funnel in one case, and more in the attrahent funnel in the second. Similar results were obtained with infertile females. Fertile females entered the attrahent funnel in greater numbers in all of three tests, but in two the difference was not significant.

These laboratory experiments failed to show that turnips are strongly attractive to cabbage maggot adults. Vodinskaya (12) recorded similar results. He collected eggs from beds of various cruciferous plants and recorded the percentage of plants from which eggs were recovered. The results were, radish 87%, cole-rape 63%, blooming cabbage 38%, head cabbage 25%, and turnips only 15%.

COPULATION

There are very few references to this topic in the literature, and probably few workers have observed the flies mating. The author rarely saw adults copulating and then only after many hours of observation. Flies remained in copulation at least one minute in such instances, and were not interrupted when other flies approached or crawled over them.

Unfed flies were not observed to copulate or oviposit. Brief mating attempts by males before feeding were observed.

PREOVIPOSITION PERIOD

Experiments by the author and other investigators indicate that the length of the preoviposition period varies considerably.

In experiments designed to ascertain the length of the preoviposition period, newly emerged flies were placed in rearing cages and supplied with food and a slice of turnip. The number of flies in a cage varied from one to 25 pairs. Usually 5% sucrose solution was supplied as food.

The preoviposition period varied from three to fifteen days. The average period for 99 females was 6.4 days, which closely approximated that obtained by other workers.

The length of the preoviposition period depends almost entirely upon how soon after emergence the flies copulate. This in turn undoubtedly depends upon the abundance of the flies in any locality, the chances of copulation increasing with larger numbers of flies.

OVIPOSITION

A review of the literature revealed that those who have worked with this insect have agreed on two points, (1) that the females spend considerable time searching for the best place to deposit their eggs, and (2) that only a small group of eggs is laid by a fly in one place at a time. They have not agreed, however, on the probable number of eggs laid by a female.

Flies were observed ovipositing in the field on a few occasions and in rearing cages on many occasions. As flies live for several weeks generations overlap, and flies are active from spring until fall. Consequently, eggs are laid more or less continuously throughout the season. In 1951 the first eggs were observed by a member of our department on May 18. That year the first eggs were laid in rearing cages on May 27. In 1952 no eggs were observed in the field in the spring, but the first eggs were laid in the laboratory on May 23. Eggs were not observed in the field in the fall but second instar larvae were found in turnips at Salem on October 22, 1952. This indicated that eggs had probably been deposited during the month of October.

The females were in a state of excitement whenever they were around a turnip, and their long, flexible "ovipositors" were extended as they moved from one part of the turnip to another, searching for the most suitable location to oviposit. The same spot was often visited several times and rejected. This search often continued for as long as thirty minutes before the fly appeared satisfied and inserted her "ovipositor" in the soil close to the plant. In the laboratory, where a turnip slice in a dish was the usual ovipositional site provided, the female inserted her "ovipositor" in any space between the bottom of the dish and the turnip. She remained in this position for not more than a few seconds and then started searching for another suitable spot, her "ovipositor" still extended.

The soil near a plant, and the crevice between the stem and the soil have been recorded as the most common places to find eggs. Eggs were also found on the aerial parts of a plant by Vodinskaya (12) and by Gibson and Treherne (5). Flies kept in cages by Miles (7) laid eggs indiscriminately on the surface of the soil and on the aerial parts of the plants. Similarly, this was observed by the author, in 1951, when several hundred flies were kept in a rearing cage. Eggs were laid under the turnip slices as usual, but in addition several hundred were found on top of the turnip, on the floor of the cage, and on the tube of dental cotton which had been saturated with sucrose solution. Miles concluded that eggs were laid openly on plants in the laboratory as the limiting effects of sunlight and drought had been removed.

Temperature appeared to be the main physical factor which influenced oviposition. On very cool days the flies in the insectary were almost motionless and no eggs were laid. Very few flies were captured in sweeps in turnip fields on cool days and none were observed around the base of plants. The author did not conduct any controlled humidity experiments to ascertain the effect on oviposition, but noted that fewer eggs were laid on humid days. Vodinskaya (12) kept flies at relative humidities of 30%, 60%, and 90%, and found that the females had laid 2, 75, and 36 eggs respectively. A relative humidity near 60% appeared to be optimum.

Oviposition is strongly influenced by food supply. As found by other workers unfed flies do not oviposit. When a nectar-like solution was fed eggs were not laid. Oviposition occurred when water, dilute sucrose solution, or a concentrated sugar solution and water were provided. Nutrition of larvae also affected egg production as underfed larvae gave rise to small, short-lived adults which did not oviposit.

The female seldom lays more than a few eggs at a time. Although Gibson and Treherne (5) stated groups as high as thirty were found, Schoene (9), Vodinskaya (12) and the author found that one was the most common. In this work nine was the highest recorded.

Egg laying may extend over several weeks but most are laid within the first two weeks. In one experiment five females, which had emerged on the same date, laid 185 eggs during 45 days. Of these 102 were deposited in the first two weeks. A second sample of five females laid 206 eggs within the first fourteen days and a total of 226 in thirty-six days.

References in the literature to the total egg-lay per female are numerous. Britton and Lowry (2) considered that the average number was from fifty to sixty. The largest number observed by Brittain (1) was 103, by Caesar (4) was 117, and by Miles (7) was 122. The largest number was recorded by Vodinskaya (12) who found that a single female had laid 149 eggs. When the author placed single pairs of flies in a cage oviposition seldom resulted. Accordingly several pairs of flies were placed in each cage. As the length of life of the flies varied considerably the number of eggs found in any day was divided by the number of females alive at that time. If the total eggs deposited had been divided by the initial number of female flies the average would not have been significant. The total of average daily oviposition gave the total egg-lay per female during her life span.

The average numbers of eggs laid by *H. brassicae* in fourteen tests were: 14.1, 17.3, 17.8, 23.0, 25.8, 30.7, 42.0, 43.8, 48.5, 49.0, 51.8, 54.6, 61.7, 114.8. Results were not recorded unless at least one female lived for fourteen days. The average number of eggs laid per female under laboratory conditions in the fourteen experiments was 42.5.

There appears to be ample evidence that the eggs of the cabbage maggot mature in batches, and that each batch usually consists of forty to sixty eggs. Slingerland (10) examined a female which had died without laying any eggs and found 55 apparently fully developed eggs. O'Kane et al. (8) dissected a female and found forty nearly mature eggs. Examination of six flies by Schoene (9) revealed 21, 24, 27, 30, 39 and 54 mature eggs. Brittain (1) obtained from 20 to 50 apparently mature eggs when flies were dissected. These flies were captured in the field so it is possible that some had already deposited a number of their eggs. Flies which the author examined prior to oviposition contained from 39 to 53 eggs. The average of 42.5 eggs recorded in the author's fourteen experiments means that the average female had matured and laid one batch of eggs.

Further evidence shows that the maximum number of batches a fly can mature probably is four. Schoene (9) examined the ovarian follicles of several flies and thought that deposition of three or four batches of eggs might be possible under favourable conditions. Vodinskaya (12) stated that each ovary had four ovarioles with 26 to 28 oocytes in each ovariole. Thus a total of 2 x 4 x 28 or 224 eggs would be possible, but the eggs do not all ripen at the same time. In view of the average number of mature eggs found in the flies at one time by other workers, Vodinskaya's data suggests a maximum of four batches averaging 52 to 56 eggs per batch. In seven of the fourteen tests previously mentioned 42 to 61.7 eggs were laid, or single batches. When the number of eggs was 30 or less partial batches were deposited, and two batches when the average reached 114.8 eggs. The fly that laid 149 eggs, as recorded by Vodinskaya (12), must have matured three batches, the highest number which has been reported.

Examination of a fourteen day old unmated female revealed only one egg, which was of normal shape and size but very soft. No eggs were found in a sixteen day old unmated female. This suggests that flies which do not mate absorb and utilize the contents of their eggs.

THE INFLUENCE OF WEATHER ON FLIES

Temperature

The activities of the flies are considerably influenced by temperature. According to Vodinskaya (12), the temperature must be above 6°C. (42.8°F.) before development of flies from over-wintering pupae is initiated.

On warm days the flies were very active and easily disturbed. Feeding of flies in the insectary or laboratory was more frequent as the temperature increased. It seems reasonable to assume that this also occurred in the field. On very hot days movement of the flies was restricted and feeding to repletion was frequent. In the field flies appeared content to remain in a cool location during the afternoons of hot days. Sweeps were made in a turnip field at Salem on two bright, sunny days with maximum temperatures of 85°F. in the late afternoon. The sweeps were made on each day between 11:00 and 12:00 a.m., 3:00 and 4:00 p.m., and 7:00 and 8:00 p.m. The number of *H. brassicae* adults caught during these periods on the first day was 7, 1, and 12, respectively, and on the second day 4, 1, and 13, respectively. The numbers of flies captured, although the samples were small, indicated that activity was moderate in the morning, low during the hottest part of the day, and high in the early evening when the temperature moderated.

In the insectary on cool days the flies were moderately active, but few were observed feeding. They moved slowly and were not easily disturbed. In the field they remained concealed while the weather was cool and probably did not feed. On cold days the flies were immobilized. On December 22, 1952, a two-day old fly was placed in a cage in the insectary and provided with food and some debris in which it could seek shelter. The temperature in the immediate vicinity of the cage was 34°F. The fly was placed in the cage at 10:00 a.m. and it immediately flew to the top. It remained motionless for over two hours then moved slowly and stiffly down the side of the cage and into the debris. The fly was placed on the wick of dental cotton the following day, the temperature being 36°F. at the time, but it refused to feed. The next day the temperature rose to 41°F. and when the fly was taken out of the debris it moved around the cage and began to feed when it was placed on the dental cotton. This fly survived temperatures of 20 to 30°F., but perished on the sixth day when the outside temperature dropped to 11°F.

Temperature conditions were optimum for oviposition on warm days, partially satisfactory on hot days, and oviposition ceased on very cool days.

Wind

On windy days in the field flies sought shelter. Caged flies, exposed to wind, sheltered at the top or behind the wooden corners of the cage.

Vodinskaya (12) found that when flies hid in porous spaces in the soil the males were close to the surface and the females deeper. Provided that the weather is not cool, egg laying may continue during windy weather. Schoene (9) and Vodinskaya (12) found eggs in crevices in the soil and about plants where flies sheltered on windy days.

It has been claimed that fields exposed to the wind are less subject to attack by this insect. However, the only infested field found in 1952 within a wide radius of Guelph was on a hill and exposed to the full force of the wind.

Rain

Cabbage maggot flies were never observed on turnips during a moderate or heavy rain and so it is assumed that they had sought shelter. Several sweeps were attempted in a field to determine if the flies were on the undersides of the turnip leaves, but the net became too wet to remain open properly and flies that were caught were too multilated for identification. Sweeps were made immediately after a heavy rain and, from the number of flies obtained, it was apparent that their activity had returned to normal soon after the rain ceased.

Humidity

As previously shown humidity had little influence on pupae as related to emergence of adults. Feeding increased and egg deposition decreased when the humidity was high. On hot, humid days the flies were sluggish and died rapidly.

Attempts were made to determine the effect of humidity on the longevity of flies at temperatures of 70 to 75°F. The desired relative humidities were obtained by mixing concentrated sulphuric acid and distilled water in the proportions suggested by Buxton and Mellanby (3). The sulphuric acid mixtures required for specific relative humidities were kept in large jars. Smaller wide-mouthed jars, which contained three male and three female flies, were placed in the former. Jars containing the flies were provided with dental cotton wicks soaked with sucrose solution. The wicks were allowed to project through the cheesecloth covers which retained the flies. This permitted the supply of food and moisture without allowing the flies to escape. After placement of the small jars of flies, the large containers were shut with a screw top. The tops were removed for about one minute every third day to replenish the food. Temperature was held within the desired range by placing the jars in water in a large aquarium. The relative humidities tested were 20%, 70%, 80%, and 90%, each humidity being tested several times.

The averaged results of the experiment are given in Table II, which shows that the flies lived as long at a high humidity as at a low humidity. Possibly the increased mortality of the flies on hot, sultry days was due to combined effects of high temperature and high humidity, rather than to the increased humidity alone.

TABLE II

EFFECT OF RELATIVE HUMIDITY ON LONGEVITY

	No. of flies used in each test		*Average length of life of*	
Relative humidity	*Males*	*Females*	*Males*	*Females*
20%	3	3	28.7 days	11.3 days
70%	3	3	13.7 "	16.0 "
80%	3	3	30.0 "	21.0 "
90%	3	3	25.3 "	23.3 "

POPULATION PEAKS

The number of generations of this species in one year is difficult to determine accurately in the field due to overlapping of the generations. For this reason population peaks is considered a more suitable term than generations.

The author attempted to determine the number of population peaks occurring in Western Ontario during 1952 by making bi-weekly collections of adults at 17 farms in turnip growing areas. There were, however, no significant infestations in this area in 1952.

In 1952, the first fly was captured on May 2 at Puslinch in a cage placed in a field which was badly infested in 1951. The latest date on which a fly was recovered was October 22 at Salem. Taking these two dates into consideration, and assuming that a complete generation would not require longer than 45 days, there were probably four population peaks in the Guelph area. The first peak would occur in early May, the second about the end of June, the third in mid-August, and the fourth at the end of September. The dates of emergence in the Holland Marsh corresponded very closely to the last two assumed peaks mentioned above. Flies began to emerge on August 16 from pupae obtained from the Holland Marsh in early August. Adult offspring reared from these flies in the laboratory began to appear on October 1.

LONGEVITY

The length of life of *H. brassicae* adults under natural conditions has not been determined. Consequently any recorded data refer only to flies held in the laboratory or insectary.

Brittain (1) found that flies in the insectary rarely lived more than two weeks. O'Kane et al. (8) recorded an average life of 17 days for females, and 17.7 for males. Flies maintained by Schoene (9) usually lived two to four weeks when food and water were provided, and one female lived 48 days. Duration of life for the male ranged from 9 to 35 days and from 14 to 38 days for the female when fed on sugar and water by Smith (11). In one experiment the author recorded an average life of 29.1 days for females, and 19.4 for males when the flies were supplied with either a 5% sucrose solution or a concentrated sugar solution plus water.

The greatest length of life was recorded by Vodinskaya (12): one female lived for 3 months, 6 days, and another for 2 months, 14 days. The greatest length of life that this investigator observed was fifty days. This might have been exceeded but unfortunately death was caused by an insecticide used in the greenhouse. This specimen laid eggs up to 3 days before death and was still very active on the day before it was killed. The greatest length of life recorded for a male was 37 days.

HIBERNATION

H. brassicae hibernates in the pupal stage. Some workers have suggested that it is possible for the flies to hibernate in either the adult or the larval stage, but this has not been proved. In this investigation no evidence was obtained to show that overwintering in the larval and adult stage was possible.

SUMMARY

1. The pupae of *H. brassicae* can withstand many adverse conditions and still produce normal, healthy flies.

2. The adults start to emerge early in May in the Guelph area.

3. The newly emerged fly goes upward through the soil with the aid of its ptilinum. They can move through at least sixteen inches of soil.

4. The ratio of males to females is approximately 1:1. The females require several days longer than males to develop.

5. The flies are positively phototropic from the time of emergence but the reaction gradually increases from the time of emergence until they are able to fly.

6. Flies which are not fed will live only a few days . They may live for nearly two weeks when provided with water. They are short-lived when only a nectar-like solution is provided, but long-lived when both a nectar-like solution and tap water are provided. The flies probably live on nectar and water in the spring and summer, but water only in the late summer and fall when few sources of nectar are available. Flies in the laboratory prefer water to sugar solutions when both are provided.

7. The rate of mortality increases amongst flies which become gorged with food on hot days.

8. The author was unable to show in the laboratory that the flies are attracted to turnips.

9. Copulation was observed in only a few instances. The flies do not copulate prior to their first meal.

10. The length of the preoviposition period varied from three days to fifteen days, the average for 99 females being 6.4 days.

11. The female fly searches for a considerable time to find a suitable site for oviposition. The eggs are usually laid in the soil close to a cruciferous plant or in the crevice between the plant stem and the soil. In the laboratory they were laid under slices of turnip. It is thought that the eggs mature in batches, and that the maximum number of batches is four. Each batch may consist of from 40 to 60 eggs.

12. The activities of the flies are considerably influenced by temperature. Hot weather increases feeding but decreases their activity and egg laying. Cool weather decreases feeding, activity, and oviposition. A fly survived temperatures of between 20 and 30°F., but was immobilized when the temperature was below 40°F. The flies seek shelter in cool, windy, and rainy weather. Hot, humid weather increases the mortality.

13. There were probably four population peaks in the Guelph area in 1952.

14. The greatest length of life recorded for a female was 50 days, and for a male 37 days. The females lived for an average of 29.1 days and the males 19.4 days when supplied with either a 5% sucrose solution or a concentrated sugar solution plus water.

15. There is no proof that this insect hibernates in the adult stage.

ACKNOWLEDGEMENTS

The author is deeply indebted to Professor A. W. Baker, head of the Department of Entomology and Zoology, who afforded me the opportunity to conduct this project. Special thanks are tendered Dr. J. G. Oughton, the chairman of my Graduate Committee, for his assistance and valued advice on many occasions. In addition, the writer gratefully acknowledges the assistance provided by Dr. C. E. Atwood, Dr. F. A. Urquhart, Professor A. J. Musgrave and Professor H. W. Goble as members of his committee.

Professor A. J. Musgrave offered his advice on any matters pertaining to the physiology of the insect. Professor A. G. McNally permitted the writer to use his olfactometer. The kind assistance of these men is appreciated.

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CONTROL OF THE SUNFLOWER MAGGOT, *STRAUZIA LONGIPENNIS* (WIED.) (DIPTERA: TRYPETIDAE), WITH DEMETON[1]

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In Manitoba, the sunflower maggot, *Strauzia longipennis* (Wied.), was first observed on commercial plantings of sunflowers in 1948. The insect was very abundant in 1951 and a survey of the sunflower growing area showed that 96.4 per cent of plants examined were infested to the extent that the pith was largely destroyed. The importance of this damage in connection with seed yield was reported by Brink (1923) and is now being studied at the Brandon laboratory.

A brief summary of the life-history of *S. longipennis* is as follows. The insect overwinters in the soil in a puparium and the adult emerges about mid June. The flight and oviposition period last until about mid July. The eggs are deposited just beneath the epidermis of the sunflower stalk. They hatch a week later and the larvae enter the pith to feed until about the end of August, when they leave the plant and pupate in the soil.

This paper reports preliminary studies of 1953 and 1954 on the protection of sunflowers against the sunflower maggot with demeton, a systemic insecticide.

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METHODS

Emulsion concentrates containing 32[1] and 42[2] per cent demeton were obtained in 1953 and 1954, respectively; in each year emulsions containing 0.1 per cent demeton by weight were used. Sprays were applied with a gasoline-powered paint sprayer fitted with a Lincoln oil spray gun,[3] at a pressure of 50 pounds.

In 1953, at Brandon, 2 plots, each consisting of 30 sunflower plants, were covered with wire screen cages, 4 by 6 by 4 feet, on July 20, and 30 female and 26 male flies were placed in each cage for oviposition. The cages and flies were removed on July 30 and the plants in one plot were sprayed with demeton emulsion until the foliage was wet; 24 fluid ounces were used. The plants were then 4 feet high and about 10 days from beginning of bloom.

In 1954, at Altona, 5 plots, each consisting of a row of 14 to 20 sunflower plants, were covered with plastic screen cages, 2 feet by 20 feet by 18 inches, on July 8, and 4 pairs of flies per plant were placed in each cage. The cages and flies were removed on July 16 and the following treatments with the emulsion were applied on July 20. The plants were about 2 feet high and 21 days from beginning of bloom at the time of treatment.

Spray Treatment.— In a plot of 15 infested plants, 8 were sprayed to dripping with a total of 30 ounces of the emulsion, and 6 were not treated.

Soil Treatment.— A plot of 20 infested plants was divided into 2 lots of 8 plants each by removing 4 plants from the centre of the plot. In one lot, the soil within 3 inches of the base of the stem was removed to a depth of 2 or 3 inches to expose the upper roots, and 10 ounces of the emulsion were poured into each excavation and allowed to soak for 2 hours before the soil was replaced. Eight plants received no treatment; they were separated from the treated plants by more than 2 feet.

Leaf Treatment (soak).— In a plot of 15 infested plants, one bottom leaf on each of 8 plants was immersed so that three-quarters of the leaf area was in contact with the emulsion. After 22 hours of immersion the leaves were severed from the plants. Seven plants were not treated.

Leaf Treatment (dip).— In a plot of 14 infested plants, all leaves (6 to 10), except those near the bud, on each of 7 plants were dipped in the emulsion until wet, removed, and allowed to dry in the air. Care was taken to prevent contamination of the stem. Seven plants were not treated.

Evaluation of Treatments.— In late September, after maggot damage had ceased, each stalk was dissected to evaluate the treatments. Pith damage was rated from 0 to 6 as follows: 0, no visible maggot injury; 1, one tunnel less than half the length of the plant; 2, one or two tunnels more than half the length of the plant; 3, three or more distinct tunnels more than half the length of the plant; 4, 25 to 49 per cent of the pith destroyed; 5, 50 to 74 per cent of the pith destroyed; 6, 75 to 100 per cent of the pith destroyed.

A damage index was calculated from the expression $\frac{\Sigma^6 i{=}o\ (Ni \times Ri) \times 100}{T \times 6}$, where R=damage rating, N=number of plants, and T=total number of plants.

The percentage reduction in the damage index in comparison with the untreated plants gave the percentage protection.

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[1]Pittsburgh Agricultural Chemical Co., New York, N.Y.
[2]Dow Chemical Co., Midland, Mich.
[3]Model 825, Lincoln Engineering Co., St. Louis, Mo.

RESULTS AND DISCUSSION

Table I shows that a 0.1 per cent demeton spray, applied after the females had oviposited for 10 days, markedly reduced damage by the sunflower maggot. The pith was not damaged in 80 per cent of the treated plants whereas it was damaged in each of the untreated plants.

TABLE I

Percentage protection against *S. longipennis* in sunflowers treated with 0.1 per cent demeton at Brandon, 1953

Treatment	*Damage index*	*Percentage protection*
Treated, 0.8 fl. oz. per plant	7	86.5
Untreated	51	

In 1954, application of the spray after the females had been ovipositing for 8 days gave complete protection against pith damage. The same degree of protection was obtained when the emulsion was poured around the base of the stem or when the lower leaves were soaked for 22 hours. Demeton was least effective when the large leaves were dipped momentarily.

TABLE II

Percentage protection against *S. longipennis* in sunflowers treated with 0.1 per cent demeton at Altona, 1954

Treatment	*Number of plants*	*Damage index*	*Percentage protection*
Spray, 3.75 fl. oz. per plant	8	0	100
Untreated	6	59	—
Soil, 10.0 fl. oz. per plant	8	0	100
Untreated	8	71	—
Leaf soaked 22 hours	8	2	97.5
Untreated	7	76	—
Leaf dipped	7	31	55.5
Untreated	7	70	—
Check	15	59	—

These observations showed that demeton as a systemic insecticide was effective against the larvae of the sunflower maggot. The larvae must have been killed in the first instar, for examination of untreated stalks on the day of treatment showed that the eggs had hatched and the majority of larvae were in the first instar. Furthermore, the small tunnels characteristic of first-instar feeding were not found when the treated plants were dissected; these tunnels persist until the plant matures.

Most of the work on systemic insecticides concerns the effectiveness of such compounds against small, soft bodied, sucking insects such as aphids, mealybugs, and thrips. But David and Gardiner (1953, 1954) have shown that certain organic phosphorus compounds are effective against biting and chewing insects. The use of such insecticides for the control of insects that mine or bore into plant tissue may be worthy of more consideration.

SUMMARY

Application of 0.1 per cent demeton emulsion to sunflower plants after females of the sunflower maggot, *Strauzia longipennis* (Wied.), had oviposited in the plants reduced or eliminated damage to the pith, probably by killing the larvae in the early instars. The application was most effective when the whole plant was sprayed, when the root was treated, or when leaves were soaked 22 hours.

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PHOSPHORUS-32 LABELING OF THE ADULTS OF THE CABBAGE MAGGOT, *HYLEMYA BRASSICAE* (BOUCHÉ) (DIPTERA: ANTHOMYIIDAE)[1]

W. H. Foott[2]

INTRODUCTION

The distance which the adults of *Hylemya brassicae* can travel and the conditions for their dispersion have never been determined. The author attempted to establish these facts by the release of radioactive flies but was unable to obtain a sufficient number to produce significant results. However, two methods of rendering flies radioactive were developed.

METHODS

There have been several methods described in the literature for obtaining radioactive insects. Radeleff et al. (1952) added P^{32} to the food of the larvae of the screw-worm fly and produced radioactive flies. Yates et al. (1951) used three methods to obtain radioactive mosquitoes. One method was to allow the adults to bite and suck blood from rats, to which had been administered an aqueous solution of P^{32} intraperitoneally. Another method was to feed the adults on a solution of P^{32} and ten per cent sugar. The third method was to rear the larvae in water containing a given amount of P^{32}. Lindquist et al. (1951) produced radioactive house flies and blow flies by feeding them on a solution of P^{32} and sugar solution. Hoffman et al. (1951) also fed house flies P^{32} in a sugar solution, and in addition reared the larvae on a medium containing P^{32} which resulted in radioactive adults.

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As the average life of *H. brassicae* adults is only about 21 days under laboratory and insectary conditions P^{32}, which has a half-life of 14.3 days, is probably the most suitable isotope for use with this insect. Supplies of this material were obtained from the Commercial Products Division, Atomic Energy of Canada Limited, through the kind co-operation of Dr. R. S. Brown of the Department of Chemistry, Ontario Agricultural College. No chemical alterations of the material were made. A small amount of distilled water was used to rinse out the original container to obtain all the radioactive phosphorus. Counts were made with a portable monitor equipped with a Geiger-Muller tube having a window thickness of 2.12 mg./cm.^{2}.

Two methods of obtaining radioactive flies were used. (1) A portion of the radioactive phosphoric acid received was diluted to approximately 5 cc. with distilled water and poured into an atomizer. Flies were placed in a lamp chimney which had been covered at one end with cheesecloth to prevent their escape. A small portion of the radioactive solution was then sprayed into the chimney until it could be assumed that most of the flies had received some of the solution. They were then returned to a rearing cage and provided with a 5—7 per cent sucrose solution as food. A number of flies were removed periodically and tested for radioactivity. Some of these were washed thoroughly, dried, and retested to determine if the P^{32} had been absorbed or could be easily removed by rain or dew when the flies were released. In one experiment a turnip slice was provided as an inducement to oviposit and the eggs tested for radioactivity. (2) The remaining portion of each shipment of P^{32} was mixed with 100 cc. of 5—7 per cent sucrose solution. Wicks of dental cotton were soaked with the radioactive solution once a day and placed in a cage containing flies. Several flies were removed from the cage each day, tested for radioactivity, and returned to the cage. In one experiment groups of eggs which had been laid were tested for radioactivity.

PRODUCTION OF RADIOACTIVE FLIES BY SPRAYING

In 1951, two groups of approximately forty flies each were sprayed with a solution of ½ millicurie of P^{32} in 5 cc. of distilled water.

Group No. 1.—Twenty-four hours after the flies had been sprayed a number were removed from the cage and tested for radioactivity. The counts per minute ranged from 1200—1600. This count included the background count but it was not of a significant nature. The count remained the same when these flies were soaked with tap water and allowed to dry. A group of ants entered the cage on the second day after spraying and soon killed all the flies.

Group No. 2.—These flies were tested one and two weeks after spraying. The lowest reading obtained a week after spraying was 200 c.p.m., and the highest was 1600 c.p.m. Only one fly was still alive after two weeks, this gave a reading of 400 c.p.m.

In 1952, a group of approximately fifty flies was sprayed with ¼ millicurie of P^{32} in 5 cc. of distilled water. Besides being one-half the strength of the 1951 sprays, less solution was actually sprayed on the flies. One day after spraying an average of 245 c.p.m. was recorded for twenty flies. Twelve days after spraying all except two flies had died, these averaged 75 c.p.m.

The above results show that ½ millicurie of P^{32} in 5 cc. of water gave a satisfactory radioactive count. However, the length of life of the flies was short both at this rate and with the more dilute solution used in 1952.

PRODUCTION OF RADIOACTIVE FLIES BY FEEDING

In 1951, a group of one hundred flies was fed a solution of ½ millicurie of P^{32} in 100 cc. of 7% sucrose solution. The flies showed an average of 340 c.p.m. after one week of feeding. During the summer three other groups of radioactive flies were produced and released in the field. Each group consisted of only a few hundred flies, two of the tagged insects being recovered.

Two feeding experiments were performed in 1952 but the flies were retained in cages rather than being released. The feeding mixture comprised ¾—1 millicurie of P^{32} in 100 cc. of 5% sucrose solution, and was provided daily until the supply of radioactive material was exhausted. A 5% sucrose solution was then used for the remainder of the experiment. In the first test 53 newly emerged flies were used and fed the radioactive sucrose solution for thirteen days. The results are shown in Table I.

TABLE I

The radioactivity of flies which had been fed on a 5% sucrose solution containing P^{32}

No. of days after supply of radioactive food started	*No. of flies tested*	*Average no. of counts per minute*
1	3	count insignificant
2	3	300
3	3	400
4	3	340
5	7	430
6	4	425
7	7	480
8	10	820
9	11	760
10	10	840
11	7	700
12	10	960
13 (supply of P^{32} exhausted, 5% sucrose soln. only supplied from this date on)	16	640
14	10	550
15	10	490
16	10	680
17	10	570
19	10	630
22	10	360
26	9	270
34	4	120
36	2	150
37	2	140
38	2	140
39	2	110
42	1	150
43 All the flies were dead		

It will be noted that the average c.p.m. reached a peak of 960 on the twelfth day. One fly lived for 42 days and still showed 150 c.p.m.

The Geiger counter developed a mechanical defect during the second experiment and accurate results can not be shown.

A COMPARISON OF THE RADIOACTIVITY OF THE TWO SEXES

A record of the radioactivity of each sex was kept in one of the feeding experiments and it was observed that there was a significant difference in the count. A few examples of this are shown in Table II. The difference was probably due to the greater size of the female and consequently a greater capacity for food.

TABLE II

Comparison of the radioactivity of males and females when fed on a P^{32} solution

No. of days after supply of radioactive food started	*Average c.p.m. females*	*Average c.p.m. males*
9	1020	525
10	1200	585
11	1065	425
12	1340	600
13	790	490
14	740	360

Similar records were kept for flies which had been sprayed, the results being shown in Table III. There was no significant difference.

TABLE III

Comparison of the radioactivity of males and females when sprayed with a P^{32} solution

No. of days after flies sprayed	*Average c.p.m. females*	*Average c.p.m. males*
4	185	185
5	130	75
6	130	75
7	120	185
8	75	100
9	90	100

RADIOACTIVE EGGS

Eight days after a number of flies had been sprayed with ¼ millicurie of P^{32} in 5 cc. of distilled water, a group of forty eggs was laid which recorded a total of 100 c.p.m.

Four groups of eggs were laid when ¾ – 1 millicurie of P^{32} in a 5% sucrose solution was fed to a cage of flies. The observations recorded were as follows.

No. of days after supply of radioactive food started	*No. of eggs laid*	*Average radioactivity per egg*
15	126	5.0 c.p.m.
16	118	8.0 "
17	86	7.5 "
22	150	4.0 "

As the supply of P^{23} was exhausted after twelve days the flies were feeding on a 5% sucrose solution when the eggs were laid. Larvae which hatched from these eggs were tested but no significant count was obtained.

DISCUSSION

The production of radioactive flies by feeding them a radioactive sugar solution appears to be a satisfactory method. A significant count can be obtained within a few days, they retain a suitable count for a considerable period after the solution is omitted from their diet, and there is no apparent effect on their length of life or oviposition. The fact that a few days are

required to build up a suitable count is not a disadvantage. *H. brassicae* adults will only live an average of three days without food, and any flies still alive after this period must have consumed some of the radioactive solution. Therefore by waiting at least three days it can be ensured that all the flies have been tagged.

Although the counts are satisfactory they are low compared to that obtained by several other investigators. Hoffman et al. (1951) fed varying amounts of P^{32} in a dilute sugar solution to house flies. The concentrations used were 120, 60, and 20 microcuries and resulted in an average of 95,426; 37, 932; and 21,744 c.p.m. respectively. The author believes that the high count in these experiments was because the flies were provided with the liquid in a small petri dish, a method which did not prove satisfactory for *H. brassicae*. In the writer's experiments a large amount of the P^{32} was absorbed on the dental cotton and therefore would be inaccessible to the flies.

The results of the spraying experiments would indicate that this is not a satisfactory method. As shown previously only two flies were alive twelve days after a group of approximately fifty had been sprayed. There is also the possibility that a number of the flies would not receive enough of the material to provide a suitable count. The radioactive solution could not be washed off and radioactive eggs were deposited, this would indicate that the solution had been absorbed by the body of the insect. If such is the case the results disagree with those of Roth and Hoffman (1952) who found that when flies and mosquitoes were sprayed with aqueous solutions of radioactive phosphoric acid the method did not work, even if wetting agents were added.

The use of radioactive material would permit a number of interesting experiments in the study of this insect. (1) The determination of the flight range would still be a worthwhile project if a sufficient number of flies could be obtained. (2) The fact that radioactive flies can produce radioactive eggs might provide a clue to the extent and speed of distribution over a field through a check on eggs deposited after release of such flies. (3) A large group of tagged flies could be released in a field containing a given species of Cruciferae and daily collections made. The figures for the number of tagged specimens released, the number recovered, and the total number of cabbage maggot adults recovered, could be incorporated into a formula and the approximate adult population of the field determined. (4) Radioactive flies could be released in an area containing cruciferous weeds but no cultivated Cruciferae, and the roots examined for eggs. The eggs of this species are not easily separated from those of several other species. However, the radioactivity of the eggs laid by these flies would eliminate any uncertainty. The number of radioactive eggs found might help settle the controversial question as to the importance of weeds as a host.

SUMMARY

Two methods of rendering flies radioactive were developed. Either ½ millicurie or ¼ millicurie of radioactive phosphoric acid (P^{32}) was diluted to approximately 5 cc. with distilled water and sprayed on *H. brassicae* flies. The counts per minute twenty-four hours after the flies were sprayed with the stronger solution ranged from 1200 – 1600. With the weak solution the flies showed an average of 245 c.p.m. one day after they had been sprayed. Radioactive eggs were laid by some of these flies which indicated that the solution had been absorbed. As the length of life was reduced, and there is a possibility that some of the flies in any group would not receive sufficient radioactive solution, this method was not considered too satisfactory.

The production of radioactive flies by feeding them P^{32} in a dilute sucrose solution was very satisfactory. From ½ – 1 millicurie in 100 cc. of 5 – 7% sucrose solution provided a satisfactory count and there was no apparent reduction in length of life. Radioactive eggs were laid by some of the flies.

Females had a higher count than males when the flies were fed the radioactive solution. There was no significant difference between sexes when they were sprayed.

ACKNOWLEDGEMENTS

The author wishes to thank Dr. J. G. Oughton of the Ontario Agricultural College for his helpful criticism and suggestions and Dr. R. S. Brown who ordered and supervised the handling of the radioactive phosphorus.

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SUMMARY OF IMPORTANT INSECT INFESTATIONS, OCCURRENCES, AND DAMAGE IN CANADA IN 1954[1]

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This summary of insect conditions was prepared from regional reports submitted by officers of the Entomology Division, provincial entomologists, officers of the Plant Protection Division, and university professors. In general, common names used are from the 1950 revision of the list approved by the American Association of Economic Entomologists. Common names other than these are accompanied by technical names. To avoid unnecessary duplication, forest insect conditions are not included, this insect group being adequately dealt with in the *Annual Report of the Forest Insect and Disease Survey,* published by the Forest Biology Division, Canada Department of Agriculture.

The summary of weather conditions was compiled from reports submitted by officers of the Entomology Division and from seasonal federal and provincial crop reports. The crop production summary was taken from the "November Estimate of Production of Principal Field Crops, 1954", Dominion Bureau of Statistics, and adjusted to agree with the February, 1955, revision of these estimates. Crop data for Newfoundland were not available. The figures on honey production were obtained from officers of the Bee Division, Experimental Farms Service, Canada Department of Agriculture.

WEATHER CONDITIONS AS AFFECTING CROPS AND INSECT PESTS IN CANADA, 1954

British Columbia experienced a comparatively mild winter excepting the month of January, which was somewhat colder than average. From March through spring and summer to November, the mean temperature for each month was slightly to considerably below the long-term average.

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Early-season precipitation was normal, but cool weather during spring and early summer delayed farm operations and retarded growth. Frosts from April 28 to 30 severely damaged buds of apricot, peach, cherry, and pear in the Okanagan Valley. Frequent showers in July stimulated excellent growth on ranges, which continued in better than average condition well into September. Irrigated forage crops yielded well, but cool, showery weather during harvest caused considerable spoilage and lowered quality. Cereal crops in dryland areas were the best on record. Vegetable crops although late were good, except that tomatoes were well below average in quality and quantity.

In the Prairie Provinces the winter was mild and in many areas the summer was one of the wettest on record. Cold weather and snow in April and heavy rains in May and June retarded seeding and plant growth, especially in northern Manitoba, northeastern Saskatchewan, and central, western, and northern Alberta. Wheat acreages were reduced and coarse grains and summer-fallow correspandingly increased. Weed growth was heavy in many crops, but hay and pasture yields were good. Crop deterioration resulting from lack of moisture occurred only in the southern, east-central, and Peace River areas of Alberta and in southwestern Saskatchewan. Rust infection began to develop in June and continued through July. During the wet weather in August it developed to such an extent in Manitoba and Saskatchewan, and to a lesser extent in eastern Alberta, that yield and grade were markedly reduced, durum wheat being largely ruined. Hail damage was fairly severe in Manitoba, light to medium in Saskatchewan, and heavy in Alberta. These losses, already extensive, were increased further in September by frost and by unfavourable, wet, cool weather during harvest operations. Warm, dry weather in October facilitated completion of harvesting. Excess moisture and low temperatures curtailed damage by wireworms in 1954 and potential damage by cutworms in 1955. The amount of egg-laying by grasshoppers was also greatly reduced.

In Ontario, overwintering crops came through in good condition. Cool, wet weather during April delayed seeding, but by the end of May it was completed in all except a few eastern counties and in northern districts. Cool weather continued in June and rains toward the end of the month and in July interfered with haying especially in eastern and northern areas, where operations continued through August and much hay was seriously damaged or lost. A prolonged drought in extreme southwestern Ontario adversely affected many crops, especially hay. Quality and quantity of the fall wheat crop was generally good. Dry weather in southcentral and southwestern areas adversely affected pastures during July. Weather conditions greatly curtailed damage by wireworms, the European corn borer, and the seed-corn maggot, but infestation by the potato leafhopper was the worst on record; the pea aphid was very numerous and the boxelder bug occurred in outbreak numbers. Yields of grain were generally good, but wet weather interfered with harvesting, especially in eastern Ontario, causing deterioration and in some cases complete loss. It ruined a large percentage of the field bean crop and some turnips and favoured late blight, which caused extensive losses in potatoes and tomatoes. Harvesting of all late crops was carried out under great difficulties. Soybeans, sugar beets, flax, husking and fodder corn, turnips, clover seed, and some grain remained in fields until November. In some areas husking corn and soybeans were harvested after the ground froze enough to carry machinery. Many crops in low areas were not harvested at all. Hurricane Hazel cut a wide swath through south-central Ontario, causing heavy losses through flooding and silting of land and crops, drowning of livestock and poultry, and wind and water damage to buildings, bridges, fences, and dams. The Holland Marsh area was completely flooded.

Little winter-killing of crops occurred in Quebec, but a late, cool spring delayed growth and interfered with seeding. Adverse weather conditions persisted until mid June and seeding was not completed until about the end of the month. Grain and canning crop acreages were reduced in many districts. However, conditions favoured pastures and hay, the latter crop being heavier than average. Rains continued to be frequent throughout the summer months with the result that haying operations continued into late August. Quality was greatly reduced and much of the crop was stored as silage. During July some yellowing of cereal crops occurred in low areas and aphids, rust, and the armyworm made their appearance in many districts. Pastures continued in excellent condition, but by mid-August some low areas were being

damaged by the feet of livestock. Small-fruit crops were generally good. Tobacco, canning crops of green peas and beans, and most vegetable crops were good. Tomatoes ripened slowly and both this crop and potatoes were seriously affected by late blight in many areas. By harvest time grain crops had been considerably reduced by lodging, rust, and smut. Aphids and the armyworm took a minor toll in some areas, but the season generally was unfavourable to the development of most insects and there were few major infestations.

In the St. Lawrence Gulf region, clovers and fall grain came through the winter in good condition. The weather was cool and dry during the planting season except in Newfoundland, where is was cool and wet. Some delay was caused by rains toward the end of seeding in some areas of New Brunswick. Cool weather persisted well into June in most areas, slowing growth of most spring crops, but hay, pasture, and early-sown grain made good progress. Some rotting of potato seed pieces occurred and in New Brunswick two-thirds of the early lettuce crop was ruined. July was rather dry in Nova Scotia and Prince Edward Island, adversely affecting some crops, but suitable for haying; in New Brunswick conditions remained cool and wet; and cool weather retarded growth also in Newfoundland. August was generally wet. Haying was delayed and much of the crop in all of the provinces was either harvested in poor condition or spoiled; Newfoundland possibly experiencing the most unfarourable conditions. Considerable lodging of grain was reported. Some late blight appeared on potatoes in New Brunswick, Nova Scotia, and Prince Edward Island during late July and some scab developed on apples in Nova Scotia. Ideal harvest weather prevailed in late August and early September. Grain yields generally were average or better. The dry weather retarded potato blight in Nova Scotia and Prince Edward Island and a good crop was harvested. In New Brunswick early potatoes yielded well, but the late crop was reduced from 30 to 60 per cent. Corn was stunted and the yield down 40 to 50 per cent. The apple crop in Nova Scotia was better than expected. Insect damage generally was about average, the armyworm outbreak not causing serious losses.

CROP PRODUCTION SUMMARY FOR CANADA, 1954

At the beginning of August, prospects were good for above-average yields in Canada's major grain crops. During the month, however, estimates were sharply reduced by the most severe rust epidemic on record in the Prairie Provinces and by extensive losses caused by sawflies, hail, wind, and excessive moisture. Frosts in the latter part of September also seriously damaged immature crops and unfavourable weather conditions during harvest in many parts of Eastern as well as most of Western Canada took a heavy toll. These losses lowered the average yields of all but two crops (sugar beets and rapeseed) below the levels of 1953. However, average yields of all but six crops (spring wheat, oats, barley, buckwheat, dry beans, and soybeans) were still above the long-time average.

Production estimates of 14 of the 21 crops included in this report were below those of 1953. Included in this group were spring wheat and all rye, each less than half the size of the 1953 crop; barley and peas, down by one-third; and oats and potatoes, each down by about one-quarter from 1953. Although reductions in acreage were a factor in all of these crops except oats, sharp drops in yields from those of 1953 were largely responsible for lower outturns. Other crops with smaller indicated production thon in 1953 were winter wheat, mixed grains, buckwheat, beans, hay, fodder corn, and field roots.

Crops exceeding the 1953 levels of production were flaxseed, corn for grain, soybeans, sunflower seed, rapeseed, mustard seed, and sugar beets. Increased acreages were largely responsible for the larger outturns of these crops since average yields were lower than in 1953 for all except rapeseed and sugar beets. Despite lower average yields than in 1953, production of both soybeans and corn for grain set new records.

WHEAT.– Production of wheat in Canada in 1954 was estimated at 298.9 million bushels, the smallest crop since 1943 and less than half of either the 1953 or 1952 crop. It was also far below the ten-year (1944-1953) average of 456.5 million bushels. The sharp drop from 614 million bushels in 1953 resulted from a five per cent decrease in acreage combined with an

average yield of only 12.3 bushels per acre, little more than half that of 1953. The long-time average wheat yield for Canada is 16.7 bushels per acre. The 1954 average yield, the lowest since 1937, was attributable to an unusual combination of adverse weather conditions, including damage from flooding, hail, wind, frost and snow, the worst rust epidemic on record in the Prairie Provinces, and extensive damage by sawflies. In addition to severe losses in yield, the 1954 Western wheat crop also suffered serious deterioration in quality.

The 1954 crop of spring wheat, including durum, was estimated at 274.8 million bushels, compared with the 1953 next-to-record 587.8 million. Part of the decrease was attributable to a reduction in seeded area from 24.8 million to 23.6 million acres, but the major factor was the sharp drop in yield to 11.7 bushels per acre, less than half the 1953 level of 23.7 bushels. Production of winter wheat in Ontario, the major producing area for that crop, was estimated at 24.1 million bushels as against 26.2 million in 1953. The reduction resulted from a drop in the seeded area from 732,000 to 710,000 acres and in average yield from a record 35.8 to 34.0 bushels per acre.

In the Prairie Provinces the 1954 wheat crop was estimated at 272 million bushels, less than half the 1953 next-to-record crop of 584 million. The estimated average yield for the Prairie Provinces as a whole was 11.6 bushels per acre, in sharp contrast to 23.7 bushels in 1953. Provincial average yields, in bushels per acre, with 1953 figures in brackets, were estimated as follows: Manitoba, 12.8 (20.8); Saskatchewan, 9.7 (23.3); and Alberta, 16.2 (25.7). The Saskatchewan wheat crop was estimated at only 151 million bushels, down by 224 million from 1953 and the smallest since 1943, when acreage was abnormally low. Production in Alberta was placed at 95 million, 68 million lower than in 1953 and the smallest crop since 1945. Manitoba's wheat crop was estimated at 26 million bushels, the smallest since 1935 and 20 million bushels below the 1953 outturn. Durum wheat in the Prairie Provinces, as well as relatively small quantities of winter wheat in all provinces except Ontario, are included in the spring wheat estimates in this report.

Despite a sharp increase over 1953 in the area seeded to durum wheat, the 1954 crop was estimated at 6.6 million bushels, 2.2 million below that of 1953. The sharp reduction in average yield per acre in the Prairie Provinces from 19.3 bushels per acre in 1953 to 8.9 bushels in 1954 was largely attributable to the severe rust infection on this crop in both Manitoba and Saskatchewan. In the latter province the durum wheat crop was placed at 4.6 million bushels as against 7.3 million in 1953. Manitoba's crop, at 400,000 bushels, was only half that of 1953, but production in Alberta, estimated at 1.6 million bushels, was almost three times the 1953 crop of 545,000 bushels.

OATS.— Production of oats for grain, placed at 306.8 million bushels, was the lowest since 1947 and 25 per cent below the 1953 outturn of 407.0 million bushels. Average production of oats in Canada for the ten-year (1944-1953) period was 399.0 million bushels. Despite an increase in seeded area from 9.8 million acres in 1953 to 10.2 million acres in 1954, lower average yields in all provinces more than offset the effect of increased acreage. The average yield for Canada as a whole was placed at 30.8 bushels per acre as against the 1953 average of 41.4 and the long-time average of 31.6 bushels per acre. Production in the Prairie Provinces was estimated at 196 million bushels, 80 million less than in 1953, with Saskatchewan accounting for 86 million; Alberta, 74 million; and Manitoba, 36 million bushels.

BARLEY.— The 1954 barley crop, estimated at 175.5 million bushels, was one-third less than the 1953 outturn of 262.1 million and also slightly below the ten-year average of 188.8 million. The 1954 crop, seeded on an area estimated at 7.9 million acres, was the smallest since 1950. Although the seeded acreage was some 12 per cent below that of 1953, lower average yields in all provinces were a major factor in reducing the 1954 crop. For Canada as a whole, the average yield was estimated at 22.3 bushels per acre, compared with 29.4 bushels in 1953 and the long-time average of 24.7 bushels. The Prairie Provinces produced an estimated 167 million bushels, compared with 251 million in 1953. In Alberta, the crop was placed at 70 million bushels, and Saskatchewan and Manitoba accounted for an estimated 53 million and 44 million, respectively.

RYE.—Sharp decreases in the area seeded to both fall and spring rye, together with lower yields in all provinces, resulted in a crop slightly less than half that of 1953. The combined production of fall and spring rye was estimated at 14.2 million bushels, compared with 28.8 million in 1953 and the ten-year average of 15.6 million. Some 11.9 million bushels was fall rye, averaging an estimated 17.7 bushels per acre, and the spring rye crop was placed at 2.3 million bushels, averaging 12.7 bushels per acre. All but 2.0 million bushels of the 1954 rye crop was grown in the Prairie Provinces, Saskatchewan's 6.7 million accounting for over half of the prairie crop of 12.2 million.

OILSEEDS.— The 1954 production of each of the four oilseed crops for which estimates were available exceeded that of 1953, almost entirely as the result of substantial increases in acreage. The flaxseed crop, estimated at 11.3 million bushels, was 14 per cent above the 1953 outturn of 9.9 million and also well above the ten-year average of 9.3 million. Seeded acreage increased from 972,000 acres in 1953 to 1,206,000 in 1954, but average yield dropped slightly from 10.2 to 9.4 bushels per acre. The flaxseed crop in the Prairie Provinces was estimated at 11.0 million bushels of which Saskatchewan accounted for 4.8 million; Manitoba, 4.0 million; and Alberta, 2.2 million.

Soybean production, carried on commercially in Ontario only, set a new record of 4.9 million bushels, compared with the previous high of 4.4 million in 1953. This year's record outturn resulted from an expansion in seeded acreage, since the estimated yield, 19.5 bushels per acre, was slightly below the 20.4 figure of 1953.

Production of both rapeseed and sunflower seed also showed sharp increases over 1953. The 1954 rapeseed crop, estimated at 40.5 million pounds, was up by 57 per cent over the 1953 revised estimate of 25.9 million and was second only to the record 64.0 million pounds harvested in 1948. In Saskatchewan, the major production area, the crop was estimated at 33.3 million pounds from a seeded area of 37,000 acres averaging 900 pounds per acre. Manitoba's rapeseed crop was placed at 7.2 million pounds from a seeded area of 9,000 acres yielding an estimated 800 pounds per acre. Production of sunflower seed in Manitoba, the only province growing this crop commercially, was estimated at 13 million pounds, more than three times the 1953 crop of 4.0 million. The sharp increase over 1953 was due entirely to the increase in seeded area from 4,500 acres in 1953 to 20,000 in 1954, since average yields dropped from 880 to an estimated 650 pounds per acre.

MIXED GRAINS.— Production of mixed grains, grown chiefly in Eastern Canada, was estimated at 61.4 million bushels, below the 62.2 million of 1953 but above the ten-year average of 57.8 million. Increased acreage was responsible for the greater production in 1954, since average yields were lower than in 1953 for all provinces. The 1954 crop was harvested from a seeded area of 1.6 million acres, averaging an estimated 39.8 bushels per acre.

DRY PEAS AND BEANS.— The 1954 production of dry peas was estimated at 880,000 bushels, well below the 1953 crop of 1,210,000 and the ten-year average of 1,282,000. The dry bean crop, placed at 1,027,700 bushels, was some 16 per cent below the 1953 outturn of 1,219,500 and far below the ten-year average of 1,425,000. Both acreage and average yield of dry peas were below 1953 levels. A moderate increase took place in the acreage of dry beans but the yield was well below that of 1953. Practically all of the beans were grown in Ontario.

CORN FOR GRAIN.— Production of shelled corn was estimated at a record 22.3 million bushels, 7 per cent over the 1953 crop of 20.9 million and sharply above the ten-year average outturn of 13.6 million. The increase over 1953 was entirely attributable to an increase in seeded area from 362,000 acres in 1953 to an estimated 418,000 acres in 1954, since average yields dropped from 57.6 to 53.4 bushels per acre. With the exception of an estimated 419,000 bushels in Manitoba, all of this crop was produced in Ontario.

BUCKWHEAT.— The 1954 crop of buckwheat, grown chiefly in Ontario and Quebec, was placed at 2.1 million bushels, compared with 3.2 million in 1953 and the ten-year average of 4.1 million. Decreases in both seeded area and average yields were responsible for the indicated drop of some 32 per cent from the 1953 crop.

POTATOES.— Canada's 1954 potato production was estimated at 50.3 million bushels, 25 per cent below the yield of 67.0 million in 1953 and the smallest crop since 1951. The sharp drop from 1953 resulted from decreases in seeded acreages and average yields per acre in all provinces (except Alberta, where the acreage remained unchanged). Excessive moisture in Quebec and the Prairie Provinces during September and October caused further sharp drops in both yield and quality of the crop.

FORAGE CROPS.— Production of tame hay, including clover and alfalfa, was estimated at 19.5 million tons, slightly below 1953's 19.6 million but above the ten-year average of 18.4 million. With the major exception of parts of southwestern Ontario, weather conditions promoted the growth of a heavy crop. However, frequent rains over many parts of the country unduly prolonged haying operations and caused considerable spoilage and deterioration in quality. Production of fodder corn was estimated at 3.0 million tons, some 17 per cent below the 1953 level of 3.6 million as the result of decreases in both seeded acreage and average yields per acre.

SUGAR BEETS.— Production of sugar beets in the four beet-growing provinces was estimated at 1,003, 853 tons, one of the largest crops on record. It was above both the 1953 level of 900,000 and the ten-year average of 802,000, but well below the 1950 record of 1,119,000 tons. Most of the increase in production over that of 1953 was attributable to an increase of 6,000 acres in acreage in Manitoba. Production in Alberta, the major beet-growing province, was placed at 440,000 tons, and the crop in Manitoba was estimated at 225,000 tons, a record for this province. In Eastern Canada, the sugar beet crops in Ontario and Quebec were estimated at 235,000 and 54,000 tons, respectively.

FIELD ROOTS.— The 1954 crop of field roots (turnips, mangels, etc.), grown chiefly for livestock feed, was estimated at 440,000 tons, 8 per cent below the 1953 outturn of 477,000 tons. With the exception of Ontario, production estimates were down from 1953 in all provinces for which estimates were available.

HONEY.— The 1954 honey crop was about 25 per cent below that of 1953, mainly because of unfavourable weather conditions during the honey-flow season. Excessive rainfall in the Prairie Provinces and drought conditions in Ontario were largely responsible. Over the ten-year period 1943-53, 50 per cent of the total honey crop was produced in Ontario and Quebec and 47 per cent in the Prairie Provinces. The number of beekeepers increased by six per cent and this was the first upward trend since 1945.

GENERAL-FEEDING AND MISCELLANEOUS INSECTS

BEET WEBWORM. — Populations in Alberta were the smallest in several years and no damage was reported in Saskatchewan and Manitoba.

BLISTER BEETLES.— In British Columbia, minor damage was reported from Cranbrook, Larkin, and Vernon. There were many reports of damage to caragana, beans, and potatoes in Alberta, where *Lytta nuttallii* Say was more numerous than usual. Little damage occurred in Saskatchewan and Manitoba. Larvae of *Epicauta subglabra* (Fall) and *E. fabricii* (Lec.) fed on grasshopper eggs in about their usual numbers in Manitoba. *E. pennsylvanica* (Deg.) caused moderate damage to aster and swiss chard in southwestern Ontario, and to potato at Ste. Anne de la Pocatiere, Que.

CRICKETS.— The Mormon cricket was only rarely reported in the Prairie Provinces. In Manitoba, the field cricket was more numerous and widespread than in 1953, notably in the southern part of the Red River Valley. It was unusually numerous also in southwestern Ontario, where it invaded many dwellings.

CUTWORMS.— The armyworm occurred during June and July in an outbreak that affected every province from Saskatchewan to Newfoundland. This was the third widespread outbreak since the turn of the century. In Saskatchewan, numbers were sufficient to cause significant damage to brome grass, rye, spring wheat, barley, and native grass at Pas Trail, Moose Range,

Tisdale, Kamsack, and Carlyle. A moderate outbreak, the first in 20 years, occurred in Manitoba affecting pasture and grain, chiefly in the Red River Valley and an area along the west side of Lake Winnipeg. Franklin gulls were a major control factor in the latter area. In Ontario, the attack affected all areas where cereal crops are grown except the counties bordering on Lake Erie. Oats were most extensively damaged; barley, wheat, timothy, corn, rye, grasses, and clover cover crops were affected to a lesser degree. In eastern counties of the Province the outbreak was the most severe in 40 years; damage to oats ran as high as 75 per cent or more and probably averaged about 20 per cent. Severe infestations and extensive crop damage were reported from many points throughout the agricultural area of Quebec. The insect was recorded in every county of New Brunswick, damage being most severe in Carleton and Victoria counties, where grain is grown extensively. In Nova Scotia, it was the outstanding pest of the season and more widely distributed than in 1953. Severe outbreaks and damage to grain, especially oats, were reported from the eastern part of Prince Edward Island, and heavy infestations in several areas of Newfoundland caused extensive damage to clover pastures.

An outbreak of the variegated cutworm occurred, more or less concurrently with that of the armyworm, throughout agricultural areas of Ontario, resulting in some confusion of the species in reports. Considerable damage was done to the fruit of tomato, and to tobacco, corn, canning peas, vegetables, and ornamentals, notably the blossoms of petunia. In Nova Scotia the outbreak was the most severe and widespread on record and damage to garden crops was considerable. Populations in Prince Edward Island were generally small, but in Newfoundland heavy infestations in many areas caused severe damage to cabbage and turnips.

OTHER CUTWORM SPECIES.– In British Columbia, cutworms were generally scarce in the lower Fraser Valley and on Vancouver Island, and less troublesome than in 1953 in the fruit-growing areas of the Okanagan and Kootenay valleys. The red-backed cutworm severely damaged beans and injured asparagus and tomatoes at Brocklehurst, and was reported in scattered infestations throughout the interior of the Province and in the Kootenays. There was little evidence of damage by the black army cutworm, although damage had been widespread and severe in the interior in 1953. Minor infestations were reported from Kamloops, Elk Valley, Natal, Golden, and McMurdo.

In Alberta, as a result of continued wet seasons, the pale western cutworm was not a pest. Minor infestations of the wheat head armyworm were reported from Lethbridge, and of unidentified species from Hay River and Fairview.

In Saskatchewan, damage by the pale western cutworm was negligible and fall moth counts at Saskatoon were the lowest recorded in 30 years. The bertha armyworm was more numerous than in any year since the outbreaks of 1947 and 1948. Damage to rape varied from a trace to 23 per cent and to flax from a trace to three per cent. The population since 1948 has varied directly with the fluctuations in rape acreage. The red-backed cutworm was greatly reduced in numbers and damage was insignificant. Moth catches at Saskatoon and Melfort were the smallest on record. Damage by the wheat head armyworm, too, was insignificant, but moth catches at Saskatoon were the largest on record. Also, at Saskatoon, a climbing cutworm, *Chrysoptera moneta* (F.), was more numerous than for several years on delphinium and *Fishia discors* Grt. was present only in very small numbers.

In Manitoba, small numbers of the red-backed cutworm caused minor damage in gardens and no field damage. Other cutworm species, except the armyworm as already reported, were not observed.

In Ontario, some general damage to various crops was caused by species other than the armyworm and variegated cutworm. The black cutworm caused considerable early season damage to tobacco plants in the seed-beds and several species attacked tomato and tobacco transplants. In Quebec, damage to seedlings and transplants was about average.

In New Brunswick, the only cutworm reported other than the armyworm was the fall armyworm, which caused some damage to corn, mainly in the Lakeville Corner and Scotchtown areas.

In Nova Scotia, in addition to the armyworm, the bronzed cutworm occurred on hay at Cow Bay; the black cutworm damaged lettuce at Berwick and golf greens at Digby; *Euxoa* and *Feltia* spp. were moderately numerous; and the fall armyworm was scarce for the second successive year. The armyworm was the only species of note in Prince Edward Island, and in Newfoundland the black army cutworm augmented armyworm activities by attacking cabbage transplants, particularly in the Avalon Peninsula.

EUROPEAN EARWIG.— This introduced pest continued to be the most troublesome insect in gardens in coastal areas of British Columbia. It was reported also from the Nelson and Creston areas and was troublesome in the Okanagan Valley. It continued to spread in south-central Ontario and at St. John's, Nfld., and apparently has become established at Yarmouth, N.S.

GRASSHOPPERS.— Outbreaks again occurred generally in British Columbia. Increases in numbers along the southern border of the Province from Princeton to Roosville resulted mainly from larger populations of *Melanoplus mexicanus mexicanus* (Sauss.) and local concentrations of *M. bivittatus* (Say). *Camnula pellucida* (Scudd.) appeared to have decreased, except in the vicinity of Princeton. A general decline from the peak infestation of 1952 continued in the Nicola Control Zone, but control measures were still necessary against the major species and, for the first time, against a 1600-acre outbreak of *Amphitornus coloradus* (Thomas). In the Thompson Valley, *A. coloradus, C. pellucida,* and *M. m. mexicanus* were abundant in the Lac du Bois area and on Skedam Flats. Elsewhere in the Valley the status of *C. pellucida* changed little, but *M. m. mexicanus* decreased appreciably. Numbers changed little also in the Chilcotin area. *M. bivittatus* was of considerable economic importance and *M. bruneri* Scudd. was of secondary importance from Kersley through Quesnel to Cinema. Outbreaks of both species occurred also in the Peace River area.

In Alberta, grasshopper populations remained at a low level except for a few localized outbreaks in the Peace River area and in the extreme south of the Province, south of the Oldman and South Saskatchewan rivers. In the latter area the population was the largest in the last five years. It consisted primarily of *M. bivittatus* and *M. m. mexicanus,* averaging 10 to 20 per square yard on roadsides and running as high as 200 per square yard earlier in the year in a few concentrations. Field infestations generally were light. The extent of territory forecast as moderate for 1955 was 120 square miles and that forecast as light, 4,420 square miles.

In Saskatchewan, an outbreak in 1954 was forecast for a very small area in the Cypress Lake district. Control measures prevented damage, but numbers reached major proportions in a limited area. *C. pellucida* predominated but was associated with large numbers of *M. bivittatus.* Light to moderate densities of these species developed south of Eastend. Light infestations of *M. bivittatus* and *M. m. mexicanus* developed south of the South Saskatchewan River in the Cabri-Leader-Burstall district and spread north of the river into the Kyle-Beechy-Lucky Lake area. Adverse weather conditions and disease combined to reduce populations to the extent that only three small areas in separate districts remainded in the economic forecast for 1955. These included the Cypress Lake, Eastbrook, and Sceptre districts.

In Manitoba, grasshoppers were more general than in 1953 and infestations showed more continuity. Light adult infestations were found in the St. Elizabeth-Arnaud-Green Ridge area east of the Red River and in the Barnsley-Graysville-Carman area to the west. *M. bivittatus* predominated, *C. pellucida* was secondary, and *M. packardii* Scudd. and *M. m. mexicanus* were also present. The forecast for 1955 indicated an increase in the area and severity of infestation as compared with that of 1954. A moderate infestation was forecast in the Arnaud-Dominion City-Ridgeville-Green area, and light infestations northwest of this area and in the Barnsley-Carman-Graysville district.

In Eastern Canada, grasshoppers caused no major damage but were more numerous than in recent years in Ontario, particularly in eastern and southwestern districts, where comparatively dry conditions prevailed during the early part of the summer. In Portneuf County, Que., population counts of five to 15 per square foot were recorded. In Nova Scotia, numbers were

the smallest in several years. The coneheaded grasshopper, not previously recorded in the Province, was collected near Aylesford. In Prince Edward Island, grasshoppers were reported to be scarce.

JAPANESE BEETLE.— Traps were again placed at various points throughout southwestern Ontario and 584 beetles were captured during the season. In 1953, only 131 were taken. The greatest increase occurred at Hamilton, where over 400 were captured.

JUNE BEETLES.— In British Columbia, the only reported damage occurred at Salmon Arm, Penticton, and Erickson. In the Prairie Provinces, white grubs were of little importance. Second-year grubs caused severe damage over a wide area of Ontario. Potatoes in particular were affected. Extensive losses occurred in pastures and lawns. Other crops affected included corn, gladioli, and nursery stock. Western and extreme eastern districts were most seriously affected, damage being substantially greater than in 1951, the previous second-year white grub period in these areas. Extensive infestation was observed also between Huntsville and North Bay and in local areas westward from Sudbury to Blind River. Damage in Quebec was negligible. In New Brunswick adults were numerous in York County and caused extensive foliage injury at Marysville. The only area severely affected in Newfoundland was St. George's Bay.

LEATHERJACKETS.— Severe damage to a lawn at Northeast Margaree, Cape Breton Island, was believed to have been caused by *Tipula* sp. Similar damage has not been recorded on the mainland of Nova Scotia. Heavy infestations in lawns and grasslands were reported also from Newfoundland.

A SAGEBRUSH PEST.— A severe infestation of *Trirhabda pilosa* Blake (Chrysomelidae) occurred on sagebrush near Kamloops, the larvae feeding extensively on the foliage of the plants. About eight square miles of open, hill country at an elevation of 2500 to 3500 feet were affected.

TARNISHED PLANT BUG.— No serious crop damage by this usually common pest was reported anywhere in Canada.

WIREWORMS.—In British Columbia, *Agriotes sparsus* Lec. was found in potato land on several farms in the Ladner area. *Limonius infuscatus* Mots. caused considerable damage to potato seed at Alberni and young barley at Cobble Hill. *Agriotes obscurus* (L.) caused severe local damage to corn at Agassiz. Light to medium wireworm infestations occurred in grain in the Peace River area and wheat was damaged locally at Vernon. Greenhouse tomatoes and peonies were attacked at Kelowna.

A survey in irrigated areas of southern Alberta revealed only light wireworm damage in all areas, most being confined to high, dry knolls. In these areas, *Ctenicera aeripennis destructor* (Brown) and *Hypolithus nocturnus* Esch. were responsible for all damage. A few larvae of *Aeolus mellillus* (Say) were found during the survey. An economic infestation of *Limonius californicus* Mann. caused 45 to 50 per cent loss in sugar beets in one local low-lying area, and in another severe local damage occurred on potatoes, the wireworm involved not being determined. In northern Alberta, damage to potatoes was reported from Three Hills.

In Saskatchewan, wireworm damage, although fairly widespread, was generally less severe than in 1953. Damage to cereal crops was generally light to moderate and exceeded 25 per cent in only 17 fields out of 400 examined. Thinning exceeding 40 per cent was observed in only five of them. These occurred in the districts of Craik, Alsask, Kindersley, and Kerrobert. Moderate damage to wheat was general throughout central, west-central, and south-central regions. Damage to oats and barley did not exceed one to two per cent. In the southwest region, where crops were almost entirely spring wheat, no damage was observed in over 50 per cent of the fields and thinning did not exceed ten per cent in any. In eastern Saskatchewan, where much of the crop consisted of coarse grains, only traces of damage were noted. In the southeast, wheat on loam soil was moderately thinned. In east-central and northeast regions no damage was observed in approximately 50 per cent of the fields. In the north-central region, little

damage was observed except east and south of Prince Albert, where occasional moderate thinning of wheat was evident. In the northwest, damage generally was very light. *C. a. destructor* appeared to be more abundant than *H. nocturnus* in most areas, the reverse of conditions in 1953. Occasional *Aeolus* sp. were observed in wheat, particularly about Saskatoon. In the White Fox area, *C. a. aeripennis* (Kby.) and *C. morula* (Lec.) were present in about equal numbers.

In Manitoba, there was very little wireworm damage because of the wet season.

In Ontario, wireworm activity in southwestern counties was the least since 1949. Damage in untreated spring grain, corn, and sugar beets was light. Very little replanting of tobacco and tomatoes was necessary and damage to potatoes was much less than in 1953. In Quebec, also, wireworm activity was reported to be at a minimum.

In the St. Lawrence Gulf provinces, serious wireworm activity was reported only in Nova Scotia, where *Agriotes sputator* (L.) ruined much hay and greatly reduced yields in cereal and row crops in the North Sydney and Digby districts. The collection of *A. sputator* north of Lunenburg extended the known distribution of this species in the Province. *Aeolus mellillus* (Say), not previously reported in Canada east of Ontario, was also found in this area. Adults of *Ctenicera lobata tarsalis* (Mels.) were present in large numbers on apple buds at Burlington, N.S., in May, but damage was light. In New Brunswick, a few reports of damage to potatoes and potato seed were received. In Newfoundland, *A. lineatus* (L.) was troublesome, chiefly in the Avalon Peninsula.

FIELD CROP INSECTS

APHIDS.— In British Columbia, light infestations of grain aphids on oats were reported from the Larkin-Armstrong district and at Kelowna a heavy local infestation of the English grain aphid was reduced by parasites. In Alberta, the greenbug was found on fall wheat early in the season in the Carmangay area but dry weather reduced populations. In Saskatchewan, the English grain aphid, les common than usual, was reported only from Davidson, where it was moderately abundant on headed wheat. The greenbug, in marked contrast to conditions in 1953, was not found on any grain during the fall; the eggs had apparently hatched before plant growth was available in the spring. *Brachycolus tritici Gill.* was less abundant than in 1953 on crested wheat and intermediate wheat grasses at Saskatoon. In Manitoba, no infestations of grain aphids were observed.

The corn leaf aphid occurred in Manitoba in a severe general infestation on late barley in the Dauphin district, the first occurrence of the kind in the Province. The infestation spread east to St. Rose and west to Grandview. Infestations on late barley were reported also from Brandon, Justice, Rivers, Carman Boissevain, and Virden. Headed barley apparently was not affected. In Ontario, barley was severely attacked in the Ottawa district and light infestations on corn were reported from Essex and Kent counties. In Quebec, also, late barley was severely damaged, particularly in the Richelieu Valley and the St. John and Quebec City areas; several thousand acres were affected, several fields being a total loss. In New Brunswick the species was conspicuous on corn.

The pea aphid was present in fairly large numbers on peas and alfalfa in Alberta. In Manitoba it was present in severe outbreak for the second successive year. Soup peas and garden sweet peas were most seriously damaged, canning peas being harvested sufficiently early to escape serious injury. The infestation centred in the Red River Valley. In southwestern Ontario, approximately 1,400 acres of early canning peas in the Chatham area were severely infested, infestation being the most severe on record. At Ottawa, Ont., populations were small on red clover and very small on alfalfa. In southwestern Quebec infestation of canning and field peas was light, but populations in alfalfa and clovers were somewhat larger than in previous years. Predators were more numerous than usual in pea fields. In Nova Scotia the pea aphid appeared in considerable numbers on canning peas about two weeks earlier than usual. No severe outbreaks developed, probably because of adequate control measures.

BARLEY JOINTWORM.— Barley was seriously damaged in the more recently infested areas of Prince Edward Island. In earlier-infested areas increasing numbers of parasites restricted damage.

CHINCH BUGS.— *Blissus leucopterus* (Say) was again prevalent in western areas of Essex County, Ont. At wheat harvest, populations moved to nearby canning corn and control measures were necessary to limit damage. The outbreak was not as widespread as in 1953. In Newfoundland, *Blissus hirtus* Montd. was more numerous than in 1953 and caused severe damage to lawns.

CLOVER CATERPILLARS.— *Diacrisia* spp. occurred on alfalfa in the White Fox, Sask., district but caused no appreciable damage. *Colias* spp. were very scarce in Manitoba. In Ontario, *Grapholitha interstinctana* (Clem.) was very abundant in second-cut red clover at Ottawa, but damage to clover heads was light.

CLOVER SEED CHALCID.— Damage to red clover seed by this insect was greater than in 1953 in the vicinity of Ottawa, Ont.

CLOVER SEED MIDGE.— Some damage occurred in second-cut red clover in Carleton County, Ont.

CLOVER WEEVILS.— The alfalfa weevil was collected for the first time in Canada at Manyberries, Alta. Subsequent surveys revealed that isolated alfalfa fields along the course of the Mills River were all infested and weevils were found at Orion, Sterling, and Cranford. The parasite *Bathyplectes curculionis* (Thoms.) was generally present, suggesting that the weevil had been present for more than one year. The insect was also in Saskatchewan, known infestations being confined to the southwestern and south-central parts of the Province. None was found north of Boharm and none east of Ogema. Ninety-five larvae per 100 net sweeps were taken in one field and counts of 12 to 60 were made in other fields in the Val Marie and Simmie districts. Occasional specimens were found near Eastend, Maple Creek, Assiniboia, Boharm, and Ogema. As in Alberta, the insect probably has been present for more than a year.

In southwestern Alberta where strip farming is practised, second-brood adults of the sweet-clover weevil moved from strips of second-year sweet clover cut for hay to seedling stands in adjacent strips of grain and killed the seedlings to a distance of four rods into the strips. In Saskatchewan, notwithstanding good moisture conditions, serious damage to first-year stands of sweet clover was reported from northeastern areas. Usually damage is limited mainly to second-year stands. In Manitoba, large populations were present, as in 1953. Five to 15 per cent damage occurred on seedling sweet clover in the Brandon district in June. Large populations of second-generation adults appeared in August and first-year stands of sweet clover adjacent to second-year stands were severely defoliated, particularly in the Brandon, Treesbank, and Riverside districts. In southwestern Ontario, larvae were more numerous than in 1952 or 1953. Adults did not cause any severe damage in second-year growth, but seedlings in laboratory plots at Chatham were severely attacked.

In British Columbia, the pea leaf weevil caused considerable damage to seedling peas in some areas. *Sitona tibialis* (Hbst.) occurred on alfalfa in northeastern Saskatchewan but caused little damage. At Ottawa, Ont., damage to red clover by *Tychius stephensi* Schönh. was not serious and *Tychius picirostris* (F), recorded for the first time in eastern Ontario in 1953, was abundant in nursery plots of ladino clover. In southwestern Ontario, the lesser clover leaf weevil was more injurious to red clover and alfalfa than in 1953. Little change in the status of this insect was noted in Nowfoundland.

CORN EARWORM.— Infestation in the Keremeos-Cawston, B.C., district was much reduced from that of 1953. Small numbers were observed on corn at Saskatoon and Webb, Sask. In Manitoba, the insect was more numerous than in 1953, notably in sweet corn. In southwestern Ontario, damage was not as severe as in 1953, but a few fields of husking corn showed 50 per cent ear damage; infestation in canning corn was comparatively light in this area and light to moderate in Prince Edward County. In New Brunswick, early corn escaped with little injury.

The mid-season crop suffered 5 to 20 per cent damage and late corn was severely attacked. In Nova Scotia, the insect was very scarce throughout the Province. Moderate damage occurred in Prince Edward Island, where infestation was lighter than usual, and in Newfoundland the insect continued to be of little economic importance.

EUROPEAN CORN BORER.— In Saskatchewan, infestation was the most widespread and severe since the appearance of the insect in the southeastern area of the Province in 1949. It had spread west to Rockglen in south-central Saskatchewan, north to Kamsack in east-central Saskatchewan, and throughout the Qu'Appelle Valley from Round Lake near the Manitoba boundary to Last Mountain Lake. No infestations were found in the Saskatoon district. In southeastern Saskatchewan, the percentage of infested gardens increased from 1.8 in 1951 to 66.6 in 1954. In general, in infested gardens, less than one per cent of the plants were affected, but in the extreme southeast the averag was 10 to 15 per cent. In Manitoba, populations increased greatly in southern areas. In the southern part of the Red River Valley, infestations in corn ranged as high as 35 larvae per 100 plants. Other infested areas included Virden, Pipestone, Holland, and Brandon. At Brandon, Crown millet was also attacked. In most areas of Ontario, infestation was the lightest recorded since establishment of the insect. In southwestern Ontario, the average number of borers per 100 corn plants was only 4.5, compared with 48 in 1953 and 195 in 1949. Drought conditions were largely responsible for the scarcity. In Quebec, increased infestation in sweet corn and light infestation in ensilage corn was reported. Light infestation occured in most corn fields in New Brunswick but damage was light. In Nova Scotia, normal abundance and moderate damage was reported.

FLAX BOLLWORM.— Three-fourths of all flax fields examined in west-central Saskatchewan were infested, larval populations ranging from one to 16 per 50 sweeps of a standard net. The greatest damage recorded was three per cent.

FLEA BEETLES.— In Manitoba, *Phyllotreta* spp. caused considerable damage to Argentine rape in experimental plots at Altona, but did no damage to either field rape or sugar beets. In Ontario, the corn flea beetle was generally present on corn in Essex and Kent counties, but in much smaller numbers than in 1953. Stewart's disease, carried by this beetle, caused moderate damage to some late sweet corn.

GRAPE COLASPIS.— An unusual infestation of this insect occurred in a 12-acre field of soybeans in Kent County, Ont.

HESSIAN FLY.— In Alberta, a 200-acre field of Ceres wheat in the Craddock district was severely infested, 50 per cent of the plants being damaged. At Lethbridge, Red Bobs and Thatcher varieties seeded on June 14 were infested 1.4 and 10.5 per cent respectively by the second generation. Fields nearby and seeded earlier were not noticeably affected. The insect was not reported in Saskatchewan, an unusual situation considering the heavy precipation. A single field of barley suffering 10 per cent loss was the only occurrence reported in Manitoba. In southwestern Ontario, slight damage was evident in many early-seeded fields of winter wheat, but infestation was not as severe as in 1951 or 1952.

LEGUME-POLLINATING INSECTS.— In Alberta, the flight period of *Megachile perihirta* Ckll. began late, as did also the build-up of worker populations of bumble bees. Consequently, most alfalfa had been in bloom for 10 days before these pollinators became active. Observations in a comparatively small area in Saskatchewan around Pas Trail, Nipawin, and White Fox revealed that pollinators were present in very limited numbers in alfalfa and the weather was unsuitable for their activity on many days. However, *Bombus terricola* Kby., *B. ternarius* Say *B. vagans* Sm., and *B. borealis* Kby. accomplished sufficient pollination of red clover to provide very profitable yields in the Pas Trail district. In the Nipawin and White Fox districts, where most of the land is under cultivation, honey bees accomplished enough pollination of both red clover and sweet clover to make yields profitable in many fields. In Manitoba, populations of leaf-cutter bees on alfalfa in the Wanless area were smaller than in 1953. The main species was *Megachile frigida* Sm., but *M. inermis* Prov. and *M. relativa* Cress. were common. *B. terricola* was the only bumble bee that occurred on alfalfa bloom in appreciable numbers and was

possibly more abundant than in 1953. *B. fervidus* (F.) was occasionally observed and was more numerous than in 1953. *B. ternarius* was rare. *B. vagans, B. rufocinctus* Cress., and *B. sylvicola* Kby. were the most numerous species on white dutch clover, alsike clover, fireweed, and wild vetch. Bees of the genus *Anthophora* were much less numerous than in 1953.

PEA MOTH.— A slight increase in numbers was indicated in southwestern British Columbia, where up to 10 per cent of the pods were infested in some gardens. The insect was remarkably scarce at Kentville, N.S., and moderately troublesome only in small gardens in Prince Edward Island.

PLANT BUGS.— In Saskatchewan, several species of plant bugs were the most important pests observed on alfalfa in northern districts. *Lygus* spp. were present in every field and caused severe damage in some. *Adelphocoris lineolatus* (Goeze), recorded in economic numbers for the first time in the Province in the Hudson Bay district in 1952, caused serious damage in several fields as far west as Garrick. *Adelphocoris rapidus* (Say) occurred only in small numbers. *Plagiognathus* sp., as in 1953, varied from occasional specimens to over 20 per net sweep. In Manitoba, *A. lineolatus* was more numerous than in 1953 at Wanless, and in the Turtle Mountain area little change was noted. The tarnished plant bug and *Lygus* sp. were generally abundant. At Ottawa, Ont., populations of the former were probably at the lowest level in four years on alfalfa, red clover, and birdsfoot trefoil. In June, in this area, *Plagiognathus chrysanthemi* (Wolff) was very abundant on red clover and birdsfoot trefoil, but scarce on alfalfa.

POTATO LEAFHOPPER.— In Ontario, this insect caused moderate to severe damage in most alfalfa fields in Essex, Kent, and Middlesex counties. Infestation was generally lighter than in 1953 but damage was increased by drought. Small populations on alfalfa, red clover, and birdsfoot trefoil in the Ottawa area caused little damage.

SAY STINKBUG.— Populations in Alberta increased materially after remaining at a low level for several years.

SEED-CORN BEETLE.— Two fields of corn near Wallaceburg, Ont., were so severely damaged by this insect that much replanting was necessary. This is the first known record of damage by the larvae in Kent County. Adults occur commonly every year.

SPITTLEBUGS.— Infestations of the meadow spittlebug were general in red clover, sweet clover, and alfalfa, and more severe than in 1953 in Essex, Kent, and Middlesex counties. Crop reduction in some hay fields was estimated at 60 per cent. Increased numbers were reported also in the Ottawa district but damage was not serious. In Quebec, late appearance and reduced numbers were reported.

SUNFLOWER INSECTS.— In Manitoba, the sunflower moth was present in small numbers throughout the sunflower-growing area. This was the first significant occurrence of this insect since 1944. *Phalonia hospes* Wlshm. continued to decline in population and damage was about one per cent. *Chelonus* sp., near *shoshoneanorum* Vier., and *Glypta* sp. continued as the important parasites of *P. hospes*. No damage to sunflowers by cutworms was recorded. The painted-lady did not occur on sunflowers. No specimens of *Eucosma* sp., probably *pulveratana* Wlshm., were noted. The sunflower beetle caused some damage in June but, in general, the infestation was light. *Lebia atriventris* Say, a predator of the sunflower beetle, appeared to be more abundant than in recent years. A mordellid, species undertermined, was present at Altona and Brandon in small numbers, as in 1953. The sunflower maggot remained at about the same low population level as in 1953. A trypetid, *Oedicarena diffusa* Snow., appeared to be present in greater numbers than in previous years, but caused little damage. The ragweed plant bug was abundant as in recent years. *Lygus* spp. were more abundant than in 1953. The sixspotted leafhopper was very abundant, as in 1953; the presence of aster yellows in some fields may have been associated with the presence of this leafhopper.

THRIPS.— Barley was lightly damaged by *Anaphothrips obscurus* (Mull.) at Entrance, B.C., and by thrips, mainly *Limothrips sp.,* near Altamont, Man. A thrips, believed to be *Haplothrips*

niger (Osb.), was observed in red clover in the Pas Trail, Nipawin, and White Fox areas of Saskatchewan, but no damage was evident. An undetermined species was present in many corn fields in sandy areas of Kent and Essex counties, Ont.

TOBACCO INSECTS.— In southwestern Ontario, the tomato hornworm was somewhat less numerous than in 1953. Early season infestation averaged up to 8 larvae per 100 plants in the Leamington area and mid-season infestation up to 15 larvae per 100 plants in the Ridgetown area. Light to moderate damage to tobacco was reported as far north as Port Elgin in Bruce County and Penetanguishene in Simcoe County. The tobacco hornworm, *Phlegethontius sextus* (Johan.), increased its range to include all of Essex, Kent, Middlesex, Elgin, and Norfolk counties. The degree of infestation was about the same as that of the tomato hornworm in July, but second-generation larvae were more plentiful, especially in Kent County. The green peach aphid appeared on tobacco from late July until the end of the season. Populations were heaviest along the Lake Erie shore and, in general, were lighter than in 1953, causing little damage.

WHEAT MIDGE.— Infestation in the Larkin-Armstrong-Enderby area of British Columbia was the most severe in several years.

WHEAT STEM MAGGOT.— Very little damage was reported in the Prairie Provinces during the season.

WHEAT STEM SAWFLIES.— In Alberta, distribution of *Cephus cinctus* Nort. remained approximately the same as in 1953, but populations increased, particularly in the area south of a line between Lethbridge and Medicine Hat. Damage in the area southeast of Lethbridge was the most severe on record. At Lethbridge, up to 25 per cent parasitism by *Bracon cephi* Gahan was recorded. In Saskatchewan, damage was the most severe in ten years. A marked increase, amounting to severe infestations, occurred in west-central and southwestern areas. A band of light infestation extended between these two areas from the Alberta border to Regina, and in the Regina and Weyburn areas in southeastern Saskatchewan infestation was moderate to light, where it had been severe in 1953. In Manitoba infestation was very light. Populations of *Cephus pygmaeus* (L.) were somewhat larger than in 1953 in southwestern Ontario; losses, however, were generally small, although damage amounted to 30 per cent in one local infestation.

VEGETABLE INSECTS

APHIDS.— The cabbage aphid continued to be difficult to control in southwestern British Columbia, even though cool, wet weather kept populations of most aphids at a low level. In Manitoba, cabbage, brussels sprouts, and broccoli were severely infested. Late cabbage was commonly infested in southwestern Ontario, but the species was scarce on crucifers in the Ottawa district. The green peach aphid and unidentified species damaged fields of pole beans at Kelowna, B.C., and one of them was believed to have spread yellow mosaic, which caused 50 per cent reduction in the canning crop. *Cavariella pastinacae* continued to be difficult to control on celery in southwestern and interior areas of British Columbia. The melon aphid occurred commonly on cucurbits in southwestern Ontario where not controlled. Potato aphids, mainly *Macrosiphum solanifolii* (Ashm.), continued to increase on Vancouver Island and in the lower Fraser Valley, B.C.; and in the Kelowna and Grand Forks areas, a species believed to be *Myzus persicae* (Sulz.) was present on potato in sufficient numbers to warrant control. Potatoes and tomatoes were attacked by aphids in the Saskatoon, Sask., area. No serious infestation was reported in Manitoba. In southwestern Ontario, *M. solanifolii* was more injurious to tomato and potato than in 1953, control measures being necessary on both early and late tomatoes. In Quebec, light populations of *M. persicae* and *A. abbreviata* Patch were recorded in the St. Lawrence Valley area. Total populations of all species on potato in New Brunswick were greatly reduced from those of 1953. In Prince Edward Island, *M. solanifolii* built up rapidly early in the season, but later was reduced to a minor status by wet weather; *M. persicae* appeared late but was not important. No serious infestations occurred in Newfoundland. In Alberta, the sugar-beet root aphid, although less numerous than in 1952 or 1953, was generally distributed

in beet-growing areas and caused severe damage in the western part of the Lethbridge Northern Irrigation District. In Manitoba, considerable numbers of *Pemphigus balsamiferae* Williams developed on lettuce at Winnipeg.

ASPARAGUS BEETLES.— The spotted asparagus beetle was numerous at Winnipeg, Man., but caused little damage. In southwestern Ontario it was more numerous than in 1953 and in this area and other parts of Ontario caused some damage to asparagus. The asparagus beetle, too, was more numerous in southwestern Ontario than in 1953 and caused moderate to severe damage. Both species were numerous in eastern Ontario but comparatively scarce in Nova Scotia. The egg parasite *Tetrastichus asparagi* Cwfd. was present in large numbers in southwestern Ontario.

CABBAGEWORMS.— The imported cabbageworm was numerous in many areas of Alberta and exceptionally so at Gleichen. In southeast and south-central Saskatchewan, defoliation of crucifers ranged from 40 to 80 per cent, approximately 20 per cent greater than in 1953. North of Saskatoon, damage was negligible. In Manitoba only light infestations had developed by late summer. Populations in Ontario were generally smaller than in 1953 and in the Ottawa area were the smallest since population records were begun in 1949. Damage to cruciferous crops, however, was extensive throughout the Province. Reduced populations were reported also from Quebec and the St. Lawrence Gulf provinces. The diamondback moth occurred commonly at Winnipeg, Man., and in southwestern and eastern Ontario. In the Ottawa, Ont., district it occurred in outbreak proportions for the second successive year and was more numerous than in any year since 1949. At Lincoln, N.B., populations were the smallest in three years and reduced numbers were reported also in Newfoundland. The cabbage looper was scarce in Manitoba, widely distributed but not injurious in southwestern Ontario, and almost negligible in comparison with other cabbageworms in the Ottawa, Ont., area. At Lincoln, N.B., however, it was more numerous than in any year since 1951. Populations of the purple-backed cabbageworm showed a minor increase in Newfoundland but damage was slight.

CABBAGE SEEDPOD WEEVIL.— This insect caused some loss in turnip seed crops at Ladner, B.C.

CARROT RUST FLY.— Damage to carrots generally was light in southwestern British Columbia, but some severe, local damage occurred in November on Vancouver Island. Severe second-generation damage was reported also from the Armstrong district. In Ontario, damage to commercial plantings was light, but some late home-garden crops were extensively injured. In the Holland Marsh area, neither first- nor second-generation larvae were numerous in the field, although laboratory plots were heavily infested by September. Flooding of the Marsh in October, as a result of Hurricane Hazel, killed all larvae in the carrots and in the soil, and 60 to 70 per cent of the pupae. No damage was found in carrots in Marmora Tp., Hastings County. In Quebec, damage was commonly reported, but reduced populations in the Ste. Anne de la Pocatiere district caused only slight losses. In New Brunswick, heavy local infestations at Lower Lincoln and Oromocto caused total loss of the late crop. In the Fredericton and Sussex areas, damage was light. Damage in Nova Scotia was general, but reduced from that of 1953. In Prince Edward Island, populations continued to increase and damage to commercial crops was expected to reach 90 per cent. Increased damage was reported also in the Avalon Peninsula in Newfoundland.

CELERY LEAF TIER.— About ten acres of celery in Kent County, Ont., were moderately infested by this insect and many bushels of parsley were rendered unfit for market.

COLORADO POTATO BEETLE.— In British Columbia, normal populations were present in the Kootenay districts and, for the first time in several years, control measures were necessary in the Edgewater-Golden area. Populations were below normal in southern Alberta, above the 1953 level in southern Saskatchewan, and considerably increased in the Winnipeg, Man., area. In southwestern Ontario, a full control program prevented serious damage in most potato and canning tomato crops. Emergency control measures were necessary on early tomato and eggplant. Considerable damage was reported in eastern Ontario. In Quebec, populations were not large

but increased over those of recent years. The insect was numerous where not controlled in Nova Scotia and caused only moderate damage in New Brunswick and Prince Edward Island, chiefly in small gardens.

CORN EARWORM.— In southwestern Ontario, this insect did not attack tomatoes to the extent that it did in 1953, but late corn was severely infested. An outbreak on tomatoes was reported from Caplan in the Gaspé Peninsula, Que., and occurrence on this host was above average in Newfoundland.

CUCUMBER BEETLES.— As usual, the striped cucumber beetle was the most serious pest of seedling cucurbits in southwestern Ontario and moderate damage was reported in Prince Edward County. Very little damage was reported in Quebec. In New Brunswick, the insect was very numerous on cucurbits in some areas, but less troublesome in others. Normal populations were present in Nova Scotia. The spotted cucumber beetle was present in southwestern Ontario but did not attain the late-season level experienced in 1953. Bacterial wilt, carried by both species, caused serious losses of cucumbers and melons in Essex County, Ont.

FLEA BEETLES.— For the third consecutive year, the potato flea beetle was not reported in Saskatchewan, nor was it reported in Manitoba. In Ontario it infested potato, tomato, pepper, eggplant, and tobacco, but caused little damage. In Quebec, New Brunswick, and Prince Edward Island, appreciable numbers appeared early, causing moderate damage to potato and tomato plants, but only minor populations developed in the second generation. Numbers in Nova Scotia were greater than in 1953 and in Newfoundland the insect was of minor importance. In infested areas of British Columbia, the tuber flea beetle caused severe damage where control materials were not applied. In the Kamloops district, adults extensively defoliated tomato plants in several fields and attacked potato and several species of weeds. *Phyllotreta* spp. were abundant on cabbage and sugar beets in Alberta generally, and on turnips at Cranford. Little damage was reported in Saskatchewan and numbers were reduced in Manitoba. Garden crucifers were extensively damaged in southwestern Ontario and moderately damaged in the St. John's and Conception Bay areas of Newfoundland. Also, in southwestern Ontario, the pale-striped flea beetle destroyed 25 per cent of a field of sugar beets and *Longitarsus* sp. was abundant but of minor importance on cucurbits.

LEAFHOPPERS.— Leafhoppers, mainly the six-spotted leafhopper, were abundant on carrot at Saskatoon, Scot, Prince Albert, and North Battleford, Sask. This was the most abundant species on vegetable crops at Winnipeg, Man. It was numerous on sunflower in the Altona-Morden area and on many hosts at Brandon, Man. Aster yellows was severe on carrot and lettuce in both provinces. The insect was numerous in the Holland Marsh, Ont., but little aster yellows was noticed. The potato leafhopper was scarce in Manitoba, but in southwestern Ontario the infestation was one of the most severe on record. Regular application of insecticides controlled the insect on potatoes, but practically all varieties of beans were severely attacked. Only minor damage was reported from Quebec and Newfoundland.

LEAF MINERS.— The spinach leaf miner was abundant in southwestern British Columbia. At Saskatoon, Sask., it caused minor damage to beet and spinach. No infestation was noted at Winnipeg, Man. Spotty infestations occurred on spinach, garden beets, sugar beet, and celery in southwestern Ontario. In Quebec, the insect was unusually abundant in the St. Jean, Ste. Madeleine, St. Hyacinthe, and La Presentation areas. The parsnip leaf miner, *Phylophylla fratria* (Lw.), caused severe early-season damage to parsnip in southwestern British Columbia and a cabbage leaf miner, *Scaptomyza adusta* Lw., was common at Marmora, Ont.

MAGGOTS IN ONIONS.— The onion maggot caused considerable damage in the interior of British Columbia, especially in the Kamloops, Grand Forks, and Vernon areas, where damage ran as high as 70 per cent. In Saskatchewan, onion mortality averaged 30 to 40 per cent in truck farms, approximately half that of 1953, and one to 20 per cent in dry-land gardens. In Manitoba, infestation at Winnipeg was heavier than in 1953, ranging from five to 15 per cent. Damage was reported also from Glenella, Kelloe, St. Malo, and Flin Flon. At Brandon infestation was very light. In southwestern Ontario, onions were heavily infested in the Thedford Marsh, and in the

Jeannettes Creek and Erieau Marsh areas losses of 10 to 20 per cent were reported. In the Holland Marsh damage was extensive, but not as severe as in recent years. In Quebec, the insect was less abundant than in recent years in the Ste. Anne de la Pocatiere area, but very abundant in the muckland areas at Ste. Clothilde and north of Montreal, where infestation ranged as high as 80 per cent. Infestation in mineral soil areas ranged from 15 to 20 per cent. The only damage reported in New Brunswick occurred in city gardens and no appreciable damage occurred in Prince Edward Island. In the interior of British Columbia, larvae of *Paragopsis strigatus* (Fall.) were more numerous than usual, causing extensive damage wherever onions were grown.

MEXICAN BEAN BEETLE.— In Ontario, this pest was fairly widespread on field beans in the Thedford Marsh area but damage was light. In eastern Ontario, extensive damage was done to canning crops of green beans in the Brighton district. In Quebec, local infestations were reported from Chateauguay, Huntingdon, and Rouville counties.

MITES.— Approximately 100 acres of tomatoes between Amherstburg and Dresden, Ont., were infested by the tomato russet mite. The infestation was the most severe on record and apparently originated from plants imported from Georgia, U.S.A. The two-spotted spider mite was well controlled in most areas of southwestern Ontario. At Erickson, B.C., the clover mite attacked tomato plants in cold frames.

ROOT MAGGOTS IN CRUCIFERS.— The cabbage maggot caused only negligible damage to early crucifers on Vancouver Island, B.C., but later in the season swede turnips were severely attacked. In the interior of the Province, turnips were observed to be severely damaged in the Cranbrook, Lumby, Kelowna, and Grand Forks areas, and such damage was believed to be widespread. Also, in the Kelowna area, a commercial acreage of cauliflower was 35 per cent damaged. In Alberta, ten to 30 per cent damage to rutabagas occurred in some fields in the Barnwell and Picture Butte districts, and cauliflower transplants were injured at Taber. In Saskatchewan this species was taken on crucifers at Regina Beach and Saskatchewan Beach on Last Mountain Lake, but nowhere else in the Province. In southwestern Ontario, normal damage amounting to approximately 15 per cent occurred on early crucifers. Serious infestations were reported in eastern Ontario, but in the Ottawa district infestation of early cabbage was below the average for the last eight years and damage was light to moderate. In Quebec, the insect continued to be the major pest of early crucifers. Damage in New Brunswick exceeded that of 1953, early cauliflower suffering the greatest loss. Turnips were severely tunnelled, 40 to 60 per cent loss occurring in the Sussex area. The cabbage maggot was the only species taken in the Lincoln area and it predominated in the Maugerville, Sheffield, and Sussex areas, where a survey revealed 33 to 40 per cent loss in cauliflower and 15 to 25 per cent loss in cabbage. In Nova Scotia, normal abundance and extensive damage to turnips was reported. The species caused only slight damage to cabbage and cauliflower, but serious damage to turnips in Prince Edward Island. This crop was severely attacked also in the Avalon Peninsula and Codroy Valley areas of Newfoundland. In Saskatchewan, damage to crucifers by the turnip maggot was comparable to that of 1953, except in truck farms at Craven and Regina, where 25 to 30 per cent of mature cabbage and cauliflower were killed. In Manitoba this species caused severe damage at Winnipeg and somewhat less damage than in 1953 at Brandon. Damage to radish by *Hylemya planipalpis* (Stein.) was similar to that of 1953 in Saskatchewan. At Brandon, Man., it was less than five per cent in most gardens in June and remained low in July. None was found in several gardens at Dauphin and Brandon.

SEED-CORN MAGGOT.— Despite cold, wet weather during the spring, no damage was reported in southwestern British Columbia. In Manitoba a few fields of beans were damaged 15 to 20 per cent. In Essex County, Ont., this insect was a serious pest of field corn and soybeans during the spring; re-seeding was necessary in many cases and, in others, stands were materially reduced. The maggot, a vector of blackleg disease, was associated with the failure of several crops of early potatoes where seed decay occurred. In many areas of southwestern Ontario, infestation of field beans, lima beans, and soybeans was the lightest in years, partly a result of seed treatment. Slight to moderate infestations were observed in home gardens. Two very un-

usual infestations were recorded. In one instance, at Burlington, the heads of cauliflower in a $2\frac{1}{2}$-acre plot were attacked, resulting in a general rotting condition. In the other, a 5-acre field of cucumbers was attacked, the maggots being confined mainly to the stems of the seedlings. In Quebec, only light infestations were generally reported. At Grand Lake, N.B., a considerable amount of injury was done to beans. Beans and corn were severely attacked in Nova Scotia, and in Newfoundland 75 to 90 per cent of bean and cucumber plants were destroyed in some plantings.

SLUGS.— In British Columbia, slugs caused up to ten per cent damage to tomatoes at Kamloops and were numerous in gardens in the Vernon and Creston areas. They were abundant also in gardens in irrigated sections of southern Alberta, and continued to increase in backyard gardens in Winnipeg, Man. In Ontario, extreme abundance resulted in considerable damage to cabbage, cauliflower, beans, chinese lettuce, tomatoes, and other crops. Similar reports of extensive damage were received from New Brunswick and Prince Edward Island.

SPINACH CARRION BEETLE.— *Silpha bituberosa* Lec. was reported from several areas in northern Alberta, and at Viking damaged beet, radish, rhubarb, potato, and lettuce. In Saskatchewan, spinach, cabbage, and turnip were attacked near Prince Albert.

SPITTLEBUGS.— A few fields of celery were damaged in Essex County, Ont., and lettuce was attacked in the Thedford Marsh area.

SQUASH BUG.— In southwestern Ontario this insect caused considerable damage in local gardens, but little in commercial crops of squash. Infestation in Prince Edward County, Ont., although moderate to severe, was much less serious than in 1953.

SQUASH VINE BORER.— In the area of southwestern Ontario from Oakville to Windsor, it has become almost impossible to grow susceptible cucurbits without control measures, because of this pest.

SUGAR-BEET ROOT MAGGOT.— This root maggot has become a serious pest of sugar beets in a small, sandy soil area near Steinbach, Man. Losses in some fields amounted to 50 per cent.

THRIPS.— Species of thrips, chiefly the onion thrips, caused light to moderate injury to a wide variety of crops in Essex County, Ont. These included beans, corn, cucumbers, melons, onions, peppers, soybeans, and tomatoes. Where not controlled in southwestern Ontario, the onion thrips caused severe damage to onions and to all bean crops, particularly soybeans. Damage in the Holland Marsh was not severe.

TOMATO HORNWORM.— Infestation of tomatoes was generally of little importance in Ontario, but control measures were necessary in some areas of Prince Edward County. Larval feeding on ground cherry, *Physalis* sp., was observed at Marmora, Ont.

FRUIT INSECTS

APHIDS.— *Aphis pomi* Deg. was of considerably greater importance than in 1953 in the Okanagan and Kootenay valleys of British Columbia, many growers being obliged to apply special sprays. In Ontario, also, this species was much more abundant than usual in apple-growing areas, except in Essex and Kent counties, where it was scarce. In Quebec it was present in most orchards and a serious pest in some. A general increase requiring control measures was reported in New Brunswick, but in Nova Scotia numbers were seldom large enough to damage fruit. *Anuraphis roseus* Bak., too, was of greater importance than in the previous few years in British Columbia. In Ontario, where not controlled it caused considerable damage to Spy, Courtland, and Greening apples. Infestations were generally light in Quebec. The spring hatch was moderately large in Nova Scotia, but populations failed to build up during the summer and fruit damage was light. The woolly apple aphid was somewhat more abundant than in 1953 in British Columbia orchards, even though parasitism by *Aphelinus mali* (Hald.) was general.

It was of minor importance in Ontario, Quebec, and Nova Scotia. The apple grain aphid was present in average numbers in Nova Scotia orchards. The black cherry aphid caused more damage than in 1953 in British Columbia and was more abundant than usual on sour cherry in Ontario. The green peach aphid, although generally less numerous than in 1953 in British Columbia, was difficult to control where large populations occurred. The black peach aphid was common on peach in Essex and Kent counties, Ont., but less numerous than in 1953 and not injurious. The mealy plum aphid, the most troublesome pest of plums and prunes in British Columbia, was present in average numbers. The currant aphid caused moderate damage at Pennant and Saskatoon, Sask. In Manitoba, infestation was severe at Brandon and light in the Morden area. The strawberry aphids *Capitophorus minor* (Forbes) and *C. fragaefolii* (Ckll.) were commonly found in most plantings in the Washademoak and Belleisle areas in New Brunswick.

APPLE MEALYBUG.— Effective control measures reduced this insect to a very minor status in New Brunswick and Nova Scotia.

APPLE (AND BLUEBERRY) MAGGOT.—This insect attacked hawthorn in its usual numbers in Manitoba, but apples were not infested. In Ontario a significant increase in the number of medium and heavy infestations was evident in all apple-growing areas of the Province. A severe infestation occurred also in a prune orchard in the Niagara Peninsula. The status of the apple maggot in Quebec was, in general, comparable to that of 1953 and damage in commercial orchards was light. A survey of 50 orchards in New Brunswick revealed light infestations in the variety McIntosh in 12 orchards and heavy infestations in nine, the latter being mainly small orchards. Some increase was noted in Nova Scotia, but infestation of commercial crops remained light. Moderate damage occurred in non-commercial orchards in Prince Edward Island. Infestation of blueberry by this insect was the lightest in five years in New Brunswick. Fifty-three per cent of samples from growers were free of maggots. Thirty-two per cent of the remaining samples had one to five maggots per sample and the remainder six or more. However, in two instances crops were not harvested because of severe infestations. Adverse weather conditions were believed responsible for the general scarcity. Damage in Prince Edward Island, too, was lighter than usual and in Newfoundland no infestations were observed.

APPLE SUCKER.— A definite increase in Nova Scotia made control measures necessary in many orchards.

BLUEBERRY CUTWORMS.— Cutworms and other lepidopterous larvae occurred on blueberry in New Brunswick in numbers comparable to those of 1953, with the exception of the black army cutworm which was present in greatly reduced numbers.

BLUEBERRY SAWFLIES.— *Neopareophora litura* (Klug), *Pristiphora idiota* (Nort.), and *P. bivittata* (Nort.), were less common than in 1953 in New Brunswick.

CHERRY FRUIT FLIES.— *Rhagoletis fausta* (O.S.) was not reported in Manitoba. In Ontario both this species and *R. cingulata* (Loew) were well controlled in commercial orchards. In Prince Edward Island *C. cingulata* caused minor damage in some districts.

CHERRY FRUITWORM.— Populations of this insect remained small in British Columbia. Distribution in the Okanagan evidently was still limited to East Kelowna.

CODLING MOTH.— Populations were smaller than in 1953 in British Columbia. In Ontario increased abundance was recorded in Norfolk, Essex, and Kent counties, but injury was not serious in well-sprayed orchards. Damage in eastern Ontario was the lightest in several years. Injury to pear was very light. In some areas of Quebec the codling moth continued to be a major pest, but in the Ste. Anne de la Pocatiere area populations were at a low level. The status of the insect was reduced from that of previous years in the Springhill, Keswick, and Gagetown, N.B., areas, but infestation was still general in the Province. In Nova Scotia, damage to apple was the lightest in several years.

CRANBERRY FRUITWORM.— A high level of infestation persisted in most natural and cultivated cranberry bogs in New Brunswick.

CURCULIONIDS.— The plum curculio was very abundant in Manitoba, causing considerable damage to plums at Morden and Manitou. In Ontario it was less abundant than in 1953 in plum, peach, and apricot orchards in the Niagara Peninsula and in Essex and Kent counties. It caused considerable injury to apple in Norfolk County and was increasingly injurious in eastern Ontario. It continued to be a pest of major importance in Quebec, generally, but appeared to be non-existent on the Ile aux Coudres, Charlevoix County, although a concentration of plum orchards was present. The apple curculio continued to be very scarce in Quebec. A clover seed weevil, *Tychius picirostris* (F.), was recorded at St. Hilaire, probably for the first time on apple trees in southwestern Quebec, but the infestation was not of economic importance. The strawberry weevil occurred in a severe infestation at Portage la Prairie, Man., causing considerable damage to raspberry as well as strawberry. Moderate numbers were reported from the vicinity of Quebec City, Que., and minor numbers elsewhere in the Province. Light infestations caused minor damage in the Grand Lake area of New Brunswick, but the insect was of no importance in most commercial plantings. Populations remained at a low level in the Annapolis Valey, N.S., but a slight increase was noted in the Masstown area. The only damage reported in Prince Edward Island occurred along the margins of old plantings. The strawberry root weevil was reported from Vernon, Summerland, Penticton, and Dawson Creek, B.C. It was an important pest of strawberry at Morden, Man., and occurred in a local infestation at Pembroke, Carleton County, N.B. A root weevil, probably the black vine weevil, damaged the strawberry variety Premier at Grafton and Morristown, N.S. The variety Senator Dunlop in adjoining plantations apparently was not infested.

CURRANT FRUIT FLY.— A few infestations were reported from points southeast of Saskatoon, Sask. Damage was lighter than in 1953. Normal numbers, generally, and considerable fruit loss were reported in Manitoba, although infestation was locally severe at Brandon.

EYE-SPOTTED BUD MOTH.— In the Kootenay Valley, B.C., the fruit buds of cherry were severely injured. No serious damage occurred in the Okanagan although the insect was common. Damage in Ontario was, in general, lighter than usual. The pest was generally distributed in apple orchards in Quebec, causing varying degrees of injury. In New Brunswick, numbers were considerably below average and in Nova Scotia the lowest population level in a great many years was recorded. In the latter province, parasitism by the braconid *Agathis laticinctus* (Cress.), the most important parasite of this moth, averaged 49 per cent.

FLEA BEETLES.— The hop flea beetle damaged young strawberry plants at Wyndell, B.C. The comparatively heavy infestations of the grape flea beetle in southern Ontario in 1952 and 1953 declined in 1954. Specimens of a blueberry flea beetle, *Altica sylvia* Malloch, were collected in Prince Edward Island.

FRUIT TREE BORERS.— The roundheaded apple tree borer continued to cause some mortality in young apple trees in Quebec and was less numerous than in 1953 in New Brunswick. The peach tree borer caused serious damage only in a few neglected orchards in British Columbia and was normally injurious in Ontario. The lesser peach tree borer was not as important as in 1953 in Ontario, but caused damage in many orchards, especially in Essex and Kent counties. The peach twig borer was unimportant in British Columbia. The currant borer was reported from Morden, Man.

GRAPE BERRY MOTH.— Injury was apparently becoming more widespread in the Niagara Penninsula, Ont., although serious injury occurred in only a few graperies. Damage was less than in 1953 in Essex and Kent counties.

GRAPE PHYLLOXERA.— An infestation of this insect was recorded for the first time on grapes in Manitoba, at the Canadian Experimental Station, Morden.

GREEN FRUITWORMS.— At Morden, Man., the lesser appleworm appeared to be more abundant than usual and the fall cankerworm was scarce. In Ontario, green fruitworms, in-

cluding cankerworms, were generally scarce, but were troublesome in a few orchards in eastern Ontario. In Quebec, the spring cankerworm, which caused damage of economic importance in 1952 and 1953, was extremely scarce, apparently having been reduced by a virus disease. Light infestations of *Graptolitha* spp. occurred in only a few orchards. In Nova Scotia, the fall cankerworm was quite common and increasing, control measures being necessary in some orchards in Kings County. *Lithophane* spp. and *Xylena* spp. appeared to be less numerous than in 1953, although fruit injury was moderately severe in a few orchards.

IMPORTED CURRANTWORM.— The only reports of this comparatively common pest were received from the St. Lawrence Gulf provinces. It appeared in a local outbreak at Truro, N.S., and in a few locations in the Annapolis Valey. In Prince Edward Island, slight damage occurred on gooseberry and in the St. John's, Nfld., area minor infestations caused little damage.

LEAFHOPPERS.—The bramble leafhopper, *Ribautiana tenerrima* (H.-S.) (*Typhlocyba tenerrima*), has continued to spread and become a major pest of brambles since it was first recorded in North America in the Victoria, B.C., area in 1947. Control measures are now necessary in practically all commercial plantings. Large populations of the leafhopper *Macropsis fuscula* (Zett.) persisted in commercial loganberry plantations on Lulu Island, B.C. Further spread was indicated by the first record on wild thimbleberry in the Port Kells area, approximately 28 miles northeast of the original infestation, and on cultivated raspberry in the Point Grey area, ten miles north of Lulu Island. The species is a vector of rubus stunt virus. The apple leafhopper was very abundant on apple trees in the Ste. Anne de la Pocatiere, Que., area and the white apple leafhopper was present in small numbers in most Nova Scotia orchards.

LEAF ROLLERS.— The fruit tree leaf roller was of minor importance in the Okanagan and Kootenay, B.C., areas. At Kamloops, B.C., it injured apricot and hawthorn in a local garden. In both Ontario and Quebec it was of minor importance, although some increase was noted in the latter province. The red-banded leaf roller was less abundant than in 1953 in Ontario and was readily controlled. In Quebec it continued to be a serious pest in many orchards. The gray-banded leaf roller increased slightly in Nova Scotia and caused moderately severe damage in a few orchards. Other leaf rollers occurred in small numbers. In British Columbia, filbert orchards in the lower Fraser Valley were heavily infested by the oblique-banded leaf roller. The strawberry leaf roller was a serious pest in Norfolk County, Ont. Infestations were generally lighter in the Niagara Peninsula and the Burlington-Oakville area, but some plantings required control measures. Only minor injury was noted in Newfoundland.

MITES.— In Biritish Columbia, the European red mite was unusually troublesome in southern districts of the Okanagan Valley, mainly because of developing resistance to organic phosphate control materials. The mite was less of a problem in northern areas of the Valley. In Ontario it was less abundant than usual on apple, peach, and plum in the Niagara Peninsula and Norfolk County. In eastern Ontario and in most areas of Quebec, average numbers developed somewhat later than usual and caused severe bronzing on susceptible hosts. Infestations were light in Nova Scotia orchards and very light in Prince Edward Island. The two-spotted spider mite and a yellow spider mite, *Eotetranychus carpini borealis* (Ewing), occurred only in small numbers in the Okanagan and Kootenay, B.C., valleys during the summer, but increased rapidly in September and caused considerable foliage injury. In Alberta the two-spotted spider mite heavily infested nearly every raspberry plantation in the Lethbridge and Calgary areas. In Ontario this species and a four-spotted spider mite, *Septanychus* sp., were widespread and abundant in most areas of the Province. They were particularly injurious in the Burlington-Dixie area and in a few Delicious and Spy orchards in eastern Ontario. The two-spotted spider mite was more abundant than usual in peach orchards in Essex and Kent counties, but was much less prevalent than in 1953 in the Niagara Peninsula. In Quebec this mite, along with the four-spotted species, occurred in unimportant numbers in most areas. The latter mite was recorded for the first time on apple in the Rougemont area. The clover mite was of minor importance in orchards in the Okanagan and Kootenay, B.C., valleys, and it was not reported in Manitoba. In Quebec it was a minor pest in orchards in southwestern districts, but occurred in outbreak numbers in Charlevoix County in eastern Quebec. Moderate numbers caused no

noticeable damage in Nova Scotia. The pear leaf blister mite was only moderately troublesome in young pear and apple plantings in British Columbia. In Nova Scotia it occurred more generally than usual on apple, causing local damage. Large numbers in Prince Edward Island caused general injury to pear. Eriophyid mites caused considerable foliage injury to cherry, prune, and pear in the Okanagan and Kootenay valleys in British columbia, were reported from Meadow Lake, Sask., damaged plums at Morden, Man., and occurred in large numbers in neglected apple orchards at Ste. Anne de la Pocatiere, Que. In Manitoba, *Eotetranychus pacificus* (McG.) and *E. mcdanieli* (McG.) occurred in small numbers on raspberry at Morden and the cyclamen mite caused extensive losses to strawberry growers in the Province.

ORANGE TORTRIX.— In British Columbia, the orange tortrix, reported in 1952 as a pest of peach in the Oak Bay district, then in 1953 causing damage to loganberry and raspberry in the same area, had spread to the Saanich district, where, for the first time in the Province, it caused damage to berry clusters in commercial holly plantings.

ORIENTAL FRUIT MOTH.— Populations of this pest remained at a low level in all peach growing areas of Ontario; fruit injury rarely exceeded 3.5 per cent. Larval parasitism was high, especially in the Niagara Peninsula.

PEAR PSYLLA.— An increase in numbers in British Columbia caused more damage to tree fruits than in 1953. In Ontario, infestations on pear were generally light.

PEAR-SLUGS.— The California pear-slug, as in 1953, was not particularly troublesome in British Columbia orchards. Elsewhere in Canada, the pear-slug, *Caliroa cerasi* (L.), was of little importance, although severe local damage occurred on plum at Alma, N.B., and on cherry in some areas of Prince Edward Island.

PLANT BUGS.— *Lygus* spp. were generally unimportant in British Columbia, although some cases of catfacing of peaches were reported from the south Okanagan area. In Ontario, catfacing of peach, mainly by the tarnished plant bug, was much more prevalent than usual in the Niagara Peninsula and Kent and Essex counties. In Nova Scotia, the green apple bug occurred only in trace numbers in most apple and pear orchards, but was moderately abundant in a few of the former. The mullein leaf bug caused little fruit injury. In Manitoba, the tarnished plant bug damaged strawberry beds at Morden.

A RASPBERRY BUD MOTH.— *Lampronia rubiella* Bjerk. was found on raspberry at Springhill, Kingsclear, Gagetown, and Belleisle, N.B.

RASPBERRY CANE BORERS.— *Oberea bimaculata* (Oliv.) was present in most raspberry plantations in Quebec, and particularly numerous in Montmagny County. Damage was light in New Brunswick and Nova Scotia. *Oberea affinis* Leng was not observed in New Brunswick.

RASPBERRY FRUITWORMS.— *Byturus* sp., less abundant than usual in Saskatchewan, caused only minor damage in southeastern areas of the Province. General infestation occurred along the Manitoba-Saskatchewan border, but elsewhere in Manitoba the insect was no problem.

RASPBERRY ROOT BORER.— Infestations were reported from Salmon Arm and Creston, B.C., and from Edmonton, Alta.

RASPBERRY SAWFLY.— Infestations occurred commonly, but no serious damage was reported in any province.

SCALE INSECTS.— Populations of the oystershell scale remained at a low level in British Columbia and Ontario orchards. In New Brunswick and Nova Scotia, numbers were large enough to warrant control measures in only a few cases. San Jose scale was less common than in 1953 in British Columbia and no infestations were reported elsewhere. In the Okanagan and Kootenay, B.C., valleys, the European fruit scale continued to be unimportant and *Pulvinaria* sp. was less prevalent than in 1953. *Lecanium* spp. evidently increased in the Okanagan and Similkameen valleys, particularly on apricot. In Ontario the European fruit lecanium was

generally of little importance except in neglected orchards in eastern areas, where it was numerous on Spy apples. A light infestation of scurfy scale occurred on apple at Morden, Man.

A STRAWBERRY CHLAMISUS.— *Chlamisus fragariae* Brown occurred in somewhat greater numbers than in 1953 in the Belleisle area of New Brunswick.

TENT CATERPILLARS AND WEBWORMS.— The western tent caterpillar caused extensive damage to fruit trees in coastal areas of British Columbia and a fall survey of orchards for egg masses indicated that 1955 may be a peak year for the pest. *Malacosoma* spp. were virtually absent in Saskatchewan, but in Manitoba a heavy infestation of *M. lutescens* (N. & D.) occurred on choke cherry in the Spruce Woods Forest Reserve. *Malacosoma americanum* (F.) and *M. disstria* Hbn. were greatly reduced, as compared with 1953, in all fruit-growing areas of Eastern Canada and injury was generally light. *Hyphantria textor* Harr. occurred in minor infestations on apple and choke cherry in York and Carleton counties, N.B., and was very scarce in Nova Scotia.

THRIPS.— An outbreak of the flower thrips, *Frankliniella tritici* (Fitch), occurred in Essex County, Ont. Sweet cherry, plum and peach were attacked severely, but damage was greatest on sweet cherry and plum. From 30 to 50 per cent of blossoms were destroyed by feeding and oviposition of the thrips. On sweet cherry and plum a considerable amount of russetting of fruits was caused by feeding of adults and nymphs under the protection of the calyx tissues. In New Brunswick, *Frankliniella vaccinii* Morgan occurred in increased abundance on blueberry at Lynfield, but in general remained at a low level comparable to that of 1953.

PREDATORS OF ORCHARD PESTS.— In Ontario, *Stethorus* sp., a predator of the two-spotted spider mite and the European red mite, was unusually abundant in several Essex County apple orchards. In Nova Scotia, predacious mirids and thrips were slightly scarcer than in 1953, but predacious mites were a little more numerous, particularly during the early months of the growing season. *Haplothrips faurei* Hood was found quite generally in the orchards, but in fewer numbers than in 1953. Another predacious thrips, *Leptothrips mali* (Fitch), also did not develop large populations and apparently was less generally distributed than in 1953. The most commonly occurring predacious mirids and anthocorids were *Hyaliodes harti* Kngt., *Deraeocoris fasciolus* Kngt., *Phytocoris conspurcatus* Kngt., and *Anthocoris musculus* (Say). *H. harti* was again quite abundant in a great many orchards. *D. fasciolus* and *P. conspurcatus* were generally distributed, but not as abundant as in 1953. There was an increase in numbers of *A. musculus.* The predacious mites *Typhlodromus* spp., which prey on phytophagous mites, continued to be general in distribution and occurred in increased numbers during the early part of the season, but in about the same numbers as in 1953 later in the season.

MISCELLANEOUS.— On Vancouver Island, B.C., an unidentified centipede was observed for the first time causing extensive damage to ripe strawberries. In Manitoba, large numbers of a willow leaf beetle, *Galerucella decora* (Say), caused serious injury to the flower buds of apple, pear, and other fruits, and in the Morden area heavy infestations of the apple seed chalcid occurred in unsprayed orchards. The rose chafer declined in numbers for the second successive year in Kent and Essex counties in Ontario and caused little injury elsewhere in the Province. Some injury occurred in isolated orchards in Quebec, notably at Abbotsford. A local outbreak of a leaf miner, *Lithocolletis* sp., occurred in a commercial orchard at Farnham, Que. The winter moth continued to be abundant along the south shore of Nova Scotia.

INSECTS AFFECTING GREENHOUSE AND ORNAMENTAL PLANTS

APHIDS.— The woolly elm aphid and another unidentified species severely disfigured many ornamental American elm in southern Alberta and the former was extremely abundant in Manitoba. In Saskatchewan, aphids infested golden glow and the roots of aster and fuchsia at Saskatoon and Annaheim. In Manitoba and southwestern Ontario aphids were unusually abundant and injurious on many garden flowers and shrubs. In southwestern Ontario, also, the melon aphid infested cucumbers in several greenhouses during March and April.

BLACK VINE WEEVIL.— In Ontario this weevil caused considerable damage in both nurseries and ornamental plantings, particularly to species of *Taxus* and *Astilbe.*

BOXELDER BUG.— No infestations were reported in British Columbia, but in southwestern Ontario the insect was present in epidemic numbers causing great concern to householders.

CORN EARWORM.— In Essex County, Ont., this insect caused moderate damage to greenhouse tomatoes during September and October, and to chrysanthemums in at least one greenhouse.

CUTWORMS.— The variegated cutworm caused extensive damage to a local crop of greenhouse carnations during July in Essex County, Ont.

ELM LEAF BEETLE.— Severe infestations occurred on Chinese and American elm in southwestern Ontario, and on American elm in Prince Edward County, Ont., and at Lacolle, Que.

EUROPEAN PINE SHOOT MOTH.— This insect was very destructive to pine in nurseries, ornamental and Christmas tree plantings, and windbreaks, in southwestern Ontario.

FALL CANKERWORM.— In Manitoba there was a heavy infestation in the Brandon area and extensive defoliation occurred in some sections. In the Winnipeg area, larvae were quite numerous in the spring, but defoliation was not as severe as expected. At Brandon, English sparrows were noticed feeding on larvae in great numbers and undoubtedly helped to suppress the infestation.

GREENHOUSE WHITEFLY.— Infestations in greenhouses were reported from Kelowna, B.C., Manitoba, and Essex County, Ont. In Essex County it was the most serious pest of greenhouse tomatoes and cucumbers, the fall crop being most seriously affected.

JUNIPER WEBWORM.— This insect damaged ornamentals in Penticton and Kelowna, B.C.

LILAC LEAF MINER.— Infestations were reported from Kamloops and Vernon, B.C. In Quebec, the insect, although widely distributed, was less numerous than in recent years. In New Brunswick and Newfoundland it was normally abundant.

MITES.— Practically all greenhouse operators growing cyclamen in the Victoria, B.C., area experienced heavy losses resulting from infestations of the cyclamen mite and it was reported to be troublesome also in Manitoba. In Alberta, unidentified mites severely damaged spruce windbreaks in southern districts and attacked green ash. Mite infestations occurred in greenhouses at Saskatoon, Sask., but were effectively controlled. Outdoor infestations were less severe than usual in Manitoba. In Essex County, Ont., mites of the two-spotted complex caused considerable injury to evergreens and many varieties of deciduous trees and shrubs. Many young silver maple were attacked by the maple bladder-gall mite.

PEAR-SLUG.— Cotoneaster and mountain ash in southern Alberta and cotoneaster in Manitoba were commonly infested.

PLANT BUGS.— The tarnished plant bug occurred commonly on ornamentals but no serious outbreaks were reported. In the southern part of Essex County, Ont., the four-lined plant bug was troublesome in flower gardens and borders.

ROSE INSECTS.— The rose curculio caused damage to rose comparable to that of 1953, in Alberta. Damage in Saskatchewan was general and more severe than in 1952 and 1953. Conditions were somewhat similar in Manitoba, although infestation at Winnipeg was less severe than in 1953. A rose sawfly, probably *Ardis sulcata* Cam., was recorded at Oliver and Summerland, B.C., and in Saskatchewan, a cynipid rose gall wasp attacked roses at Viscount and Langham.

SATIN MOTH.— A very large flight of adults occurred at Kamloops, B.C., in midsummer. They were attracted to blue fluorescent lights in greater numbers than to red lights. In Quebec,

populations in the lower St. Lawrence Valley were slightly larger than in 1953, and in Newfoundland epidemic numbers caused severe defoliation at Deer Lake, Gander, and St. John's.

SAWFLIES.— At Edmonton, Alta., spruce sawflies, *Pikonema* spp., were the most numerous insect pests on spruce. In Hastings County, Ont., *Pikonema alaskensis* (Roh.) occurred commonly on ornamental white and Colorado blue spruce. The willow sawfly was reported from Arborg, Man. The mountainash sawfly severely defoliated mountain ash at Fredericton, N.B., and Charlottetown, P,E.I.

SCALE INSECTS.— Infestations of the pine needle scale have been severe in the Okanagan Valley, B.C., for three to four consecutive years. In Manitoba infestation was severe at Morden and normal at Brandon and Winnipeg. A severe infestation of the walnut scale occurred on caragana at Oyama, B.C. Oystershell scale occurred locally in Lethbridge, Alta. Unspecified scale insects occurred on rose and oleander at Moose Range and Leney, Sask.

SPHINX MOTHS.— Clarkia was severely defoliated by *Celerio lineata* (F.) at Saskatoon, Sask., and by *C. galii intermedia* Kby. at Brandon and Hamiota, Man. The latter also attacked fireweed in large numbers at Wanless.

SPRUCE NEEDLE MINER.— Ornamental spruce was damaged by this needle miner at Vernon and Penticton, B.C.

TENT CATERPILLARS.— The western tent caterpillar caused extensive damage to ornamental trees in coastal areas of British Columbia. The eastern tent caterpillar and the ugly-nest caterpillar were abundant and injurious to ornamental shrubs and deciduous trees in many areas of Quebec.

TOMATO PSYLLID.— The tomato psyllid infested greenhouse tomatoes on the Experimental Farm at Lethbridge, Alta., in the first local infestation since 1942.

THRIPS.— The gladiolus thrips caused moderate damage to several acres of gladioli at Kelowna, B.C. A few infestations were reported in Saskatchewan, and in Manitoba and most areas of Eastern Canada it was frequently abundant where control measures were inadequate. The onion thrips attacked cucumber in several greenhouses in Essex County, Ont., in some cases causing moderate to severe damage.

VIRGINIA-CREEPER LEAFHOPPER.— The usual heavy infestations of *Erythroneura ziczac* Walsh. destroyed much of the foliage of Virginia creeper in Kamloops and Vernon, B.C., and in Lethbridge and other localities in southern Alberta. In Saskatchewan, reports of damage were much less numerous than usual.

INSECTS ATTACKING MAN AND LIVESTOCK

BED BUG.— In Alberta, reports of bed bugs were more numerous than for many years. A few infestations in Saskatchewan involved Saskatoon, Elrose, and Macdowall. An infestation at Winnipeg, Man., was the only record in that province, and in Ontario several occurrences in Ottawa were reported.

BLACK FLIES.— In the Cherryville region of British Columbia, populations were small during the summer, but increased to outbreak proportions in late September and October, causing considerable weight loss in cattle. Reports from most other areas of the Province indicated normal abundance. In Alberta *Simulium arcticum* Mall. was found in small numbers in irrigation canals at Lethbridge and Bassano. In Saskatchewan larvae of *S. arcticum* were more abundant than in 1953 in the South Saskatchewan River. The river was treated with larvicides and no outbreaks occurred. In the North Saskatchewan River larvae were absent during the winter and early spring for the first time since examinations began in 1948. This was apparently the result of industrial contamination; other aquatic insect and fish were also destroyed. Infestations of *S. venustum* Say were very light in the Souris River in both Saskatchewan and Manitoba, apparently because of lower-than-average water levels. Specimens of the black fly

Simulium rugglesi N. & M. were identified from Manotick, Ont., Maugerville, N.B., and the Provincial Veterinary Laboratory, Manitoba. The species is a vector of a disease of water fowl called duck malaria and in all instances the records were associated with sickness and mortality in young domestic ducks. In Newfoundland black fly infestations continued to be generally severe.

BLACK WIDOW SPIDER.— Further records were received from the North Okanagan Valley, B.C.

BLOW FLIES AND FLESH FLIES.— At Edmonton, Alta., a dipterous larva, probably *Wohlfahrtia* sp., was removed from an infant and mature larvae of *Calliphora vicina* R.-D. were collected from the floor of a living room. In Ontario, collections of the secondary screw-worm, *Callitroga macellaria* F., made at Point Pelee indicated that it was established in the area. A single specimen taken at Jordan, Ont., in 1919 was the only previous Canadian record. The insect is common in the American tropics. In Newfoundland, infestation of sheep by *Phaenicia sericata* (Mg.) continued on Bell Island, but losses from resulting myiasis were less than in 1953.

BOT FLIES.— Bot flies were commonly observed annoying horses in Manitoba, Ontario, and Quebec.

CATTLE GRUBS.— Larvae of *Hypoderma* bovis (L.) and *H. lineatum* (De Vill.) were unusually abundant on cattle at Kamloops, B.C., but mortality was high and emergence was below the average for the previous nine years. The abundance of *H. bovis,* relative to *H. lineatum,* was greater than in any other year on record. In Manitoba and Ontario, cattle grubs continued to be a major pest and the object of active control campaigns.

CULICOIDES.— Eight species of *Culicoides* were taken in light traps at Kamloops, B.C., but, although present in large numbers, they caused negligible annoyance to humans. Among those taken were numbers of *C. varipennis* (Coq.), the vector of the "blue tongue" disease of sheep. This disease is currently causing much concern in the United States, but has not, so far, been reported from Canada.

FLEAS.— Three occurrences of the human flea were reported from southwestern British Columbia. The western chicken flea was collected on a man at Edmonton, Alta., and was recorded at Lashburn, Sask. Single reports of *Ctenocephalides* spp. were received from Saskatoon, Sask., and Manitoba. Eighteen reports of infestations in homes in the Ottawa district were recorded and specimens were received from Sarnia, Port Colborne, Toronto, and Tavistock, Ont.; and Montreal and Aylmer, Que. The dog flea was common at Marmora, Ont. A rodent flea, reported as *Leptopsylla* sp., was collected at Speers, Sask.

HORN FLY.— This cattle pest was considerably more numerous than in the previous three years in eastern Ontario.

LICE.—The head louse persisted in appreciable numbers in Ottawa, Ont.; the hog louse was reported from Davidson, Sask.; and cattle lice were reported from Foam Lake and Churchbridge, Sask.

MITES.—The chicken mite attacked humans at Kitscoty, Alta., Winnipeg, Man., and Ottawa, Ont. Chickens also were attacked at Winnipeg. In most cases the mites migrated from birds' nests into dwellings, but in one case they invaded a hospital. One case of itch mite infestation was recorded at Edmonton, Alta.

MOSQUITOES.— In British Columbia, snow pool mosquitoes, *Aedes* spp., were unusually scarce in the interior because of a lack of surface water. However, the river flood water species, *Aedes vexans* (Mg.) and *A. sticticus* Mg., were very numerous over a long period in most districts. In northern Alberta, mosquito populations were not as large as in the average season. *A sticticus* was important early in the season and *A. vexans* and *A. spencerii* (Theo.) later. In Saskatchewan, because of heavy late-season precipitation, large populations of *A. vexans* and *Culiseta inornata* (Will.) occurred during August, September, and early October, probably the most severe outbreak since 1941. In Manitoba, too, infestation was in general very severe. In eastern Ontario, as in

Saskatchewan, heavy late season rains resulted in large, late populations, chiefly of *A. vexans*. In Prince Edward County, Ont., the level of Lake Ontario was the lowest since 1951. This resulted in better drainage and fewer mosquitoes in bordering low areas.

SHEEP KED.— Populations of this parasite of sheep were not believed to have changed appreciably.

SNIPE FLIES.— In regions above the 4000 foot level in British Columbia, snipe flies were annoying in parks and camp areas.

STABLE FLY.— Populations along Lake Erie, Ont., beaches, although appreciable, seemed to be somewhat smaller than in 1953.

TABANIDS.— Populations in Saskatchewan were comparable to those of 1953. The prevailing species included five of the genus *Tabanus* and five of the genus *Chrysops*. *Tabanus septentrionalis* Loew was the most abundant. In the St. Clair area of southwestern Ontario, tabanids, especially *Tabanus quinquevittatus* Wied. and *Chrysops brunneus* Hine, were very abundant and annoying. Many species were very common also in eastern Ontario, notably *Chrysops celer* O.S. Appreciable populations in Newfoundland showed little change from those of 1953.

TICKS.— In British Columbia, *Dermacentor andersoni* Stiles appeared to maintain its usual population in areas under observation. Nicola and Stump Lake concentrations were as heavy as ever, and adults at the Rayleigh site remained scarce. Surveys in the Kootenay district showed adults to be plentiful on hillsides across the bay from Nelson, and along the sides of the highway from Grey Creek to Creston. At Kamloops they appeared to be on the increase, and at benchlands adjoining residential areas, one third of a herd of 300 sheep was paralysed by engorging females. Recovery followed removal of the ticks. Apart from this, no large outbreaks of this disease occurred in 1954. Included among the five cases of human paralysis was one near-fatal case of a 3-year old boy from Ashcroft. Fortunately the tick was removed in time, although the victim was so near death that convalescence extended over three days. *Ixodes pacificus* C. & K. caused considerable annoyance to humans and dogs at Cultus Lake and Pender Harbour, B.C. The ear tick, *Otobius megnini* (Dugès), remained prevalent in the lower Okanagan Valley and Rocky Mountain sheep in the region of Vaseaux Lake were heavily infested in November. *Dermacentor albipictus* (Pack.) appeared to maintain its usual status. No soft ticks, Argasidae, were recorded in British Columbia, but at Saskatoon, Sask., two specimens of the bat tick, *Ornithodoros kelleyi* C. & K., were collected at the University. The species had not previously been recorded in Canada. At Regina and Climax, Sask., humans were attacked by unspecified ticks. In Manitoba, *Dermacentor variabilis* (Say) was very abundant in wooded areas around Winnipeg. In eastern Ontario, *Ixodes cookei Pack.* was taken on dogs at Marmora and Ottawa and nymphs, believed to be this species, were taken on children at Ottawa, Tweed, and Eganville. At Wellington, Ont., a nymphal tick, also believed to be *I. cookei*, was taken on a cat. The brown dog tick occurred in dwellings and on dogs in a considerable number of infestations in the Ottawa district. Many of these were traced to dog boarding kennels which had become quite heavily infested.

WASPS.— Wasps were unusually abundant in Manitoba, but at Ottawa, Ont., were rather less troublesome than in 1953. No outbreaks occurred in Newfoundland, where fish is occasionally severely damaged on drying racks.

HOUSEHOLD INSECTS

AN ACORN CURCULIO.— An unusual occurrence of curculios wandering about a house in Winnipeg had its source in acorns stored in the attic by squirrels.

ANTS.— Ants, as usual, caused annoyance in many buildings and infested lawns, gardens, and golf courses across the country, but identity as to species was possible only in the few cases in which specimens were collected. Carpenter ants, *Camponotus* spp., constituted the most

frequently reported and the most injurious single genus, especially in central Canada. The pharaoh ant, apparently continuing to increase in importance, was reported from British Columbia, Manitoba, Ontario, and Quebec. *Lasius niger neoniger* Emery was recorded from Winnipeg, Man., and *Myrmica* sp. from Cardinal, Ont.

BAGWORMS.— Hibernating *Solenobia* sp. occurred in numbers in a dwelling at Osgoode, Ont.

BOOKLOUSE.— A new dwelling in West Kildonan, Man., was seriously infested. Other new houses nearby apparently were not affected.

BOXELDER BUG.— This insect was only occasionally reported in the Prairie Provinces, but in southwestern Ontario it invaded dwellings in almost epidemic numbers, especially in the Chatham and Windsor areas.

CARPET BEETLES.— Reports of the varied carpet beetle greatly outnumbered those of the black carpet beetle in coastal areas of British Columbia, but the latter species was more numerous in the interior of the Province. In the Prairie Provinces the black carpet beetle was the most commonly reported household pest and this situation obtained fairly generally throughout Eastern Canada. Two isolated reports of the varied carpet beetle were received from Saskatoon, Sask.

A CHECKERED BEETLE.— Adults of *Enocleris nigripes rufiventris* (Spin.) were collected in a dwelling at Dunvegan, Ont.

CLOTHES MOTHS.— Clothes moths continued to be troublesome in dwellings, but less so than carpet beetles.

CLUSTER FLY.— A single occurrence was reported in British Columbia. Reports in Ontario and Quebec were somewhat less numerous than usual.

CRICKETS.— Camel crickets invaded basement in British Columbia, Saskatchewan, Manitoba, Ontario, and Quebec. They appeared to be most numerous in rough, rocky terrain. The house cricket was reported on several occasions at Ottawa, Ont., and the field cricket caused considerable damage to clothing and house furnishings in southwestern Ontario.

COCKROACHES.— The German cockroach was commonly reported from coast to coast, notwithstanding an adequate supply of new, effective insecticides. A faunal survey in Eastern Canada revealed a parasite and a predator of the Pennsylvania woodland cockroach, *Parcoblatta pennsylvanica* (Deg.). A minute, chalcid wasp parasitizes the eggs, and a rare sphecoid wasp provisions its nest with the nymphs and adults. Neither genus had previously been reported from Canada.

DRUG-STORE BEETLE.— Infestations were reported in Ottawa, Ont., Trail, B.C., Quebec and Prince Edward Island.

EUROPEAN EARWIG.— Spreading mainly in a northwesterly direction in southern Ontario in recent years, this insect practically reached the shore of Lake Huron in 1954.

FRUIT FLIES.— *Drosophila repleta* Woll. appeared again in several infestations in Ottawa.

A FUNGUS BEETLE.— An outbreak of *Typhaea stercorea* (L.) occurred in a new barn at Charteris, Que.

HOUSE CENTIPEDE.— Specimens of this centipede were received from Ottawa, Toronto, Hamilton, and Carleton Place, Ont.

HOUSE FLY.— Reports indicated that the house fly population was at a generally low level throughout most of Canada.

MANURE FLIES.— Large numbers of adults of the family Borboridae collected between window sash in a dwelling at Deschenes, Que. These insects breed in manure and were believed to have been seeking shelter for hibernation.

MILLIPEDES.– Numerous complaints originated at various points in Ontario concerning the invasion of dwellings and motels by millipedes ranging up to 2½ inches in length.

MITES.– The clover mite, a frequent nuisance in dwellings and an injurious pest on lawns and ornamentals, was commonly reported from the interior of British Columbia eastward to Ontario.

PARSNIP WEBWORM.– Adults of this webworm invaded dwellings in Ottawa, Ont., on at least two occasions.

PLASTER BEETLES.– A new dwelling in Ottawa, Ont., was heavily infested by these beetles.

SILVERFISH.–These insects continued to be fairly common in households and public buildings. Some two dozen complaints, nearly all originating in Ontario, were received at Ottawa and 15 at a local office in Vancouver, B.C. The buildings and connecting tunnels of a large institution at Three Hills, Alta., and a college at St. Basile, N.B., were generally infested.

SPIDER BEETLES.– Occasional reports of spider beetles in dwellings included *Ptinus ocellus* Brown in British Columbia, *P. villiger* (Reit.) in Saskatchewan, *Mezium affine* Boiel. in Toronto and Ottawa, Ont. *Niptus hololeucus* (Fald.) was commonly reported as a household pest in northern Alberta.

STRAWBERRY ROOT WEEVIL.– Invasion of dwellings by adults of this weevil was a common occurrence in Saskatchewan, Ontario, and Quebec, and doubtless in other provinces as well.

TERMITES.– *Reticulitermes* sp. was reported from Summerland, and Kelowna, B.C., and unidentified species occurred rather commonly in coastal areas of the Province.

WOOD BORERS.– The occurrence of *Lyctus planicollis* Lec. in flooring of imported oak at Medicine Hat, Alta., constituted the first record of this genus in the Province. Cerambycid larvae occurred in a building at Cardston, Alta., and unspecified wood borers at Taber and Viking, Alta. Cerambycid larvae also emerged from the walls of new dwellings at Winnipeg, Man., causing damage to plaster. Powder-post beetle damage was reported by five householders in Chatham, Ont., and an old school in Victoria, B.C., was damaged so severely that reconstruction was necessary. *L. planicollis* infested hickory furniture at Magnetawan, Ont., and *Lyctus* spp. were reported to be commonly injurious in dwellings in Newfoundland. The wharf borer was reported in the occurrence of a single adult at Ottawa, Ont., and an infestation at Montreal, Que.

STORED PRODUCT INSECTS

STORED GRAIN INSECTS.– The most serious stored product insect problems in 1954 were those associated with stored grain. The most serious insect pest continued to be the rusty grain beetle. This pest occurred in both country elevators and in grain stored on farms throughout Western Canada. In addition to the rusty grain beetle there were several infestations in which the fungus beetles *Cryptophagus* spp. and *Lathridius* spp. were present in considerable numbers. Grain mites were also present in stored grain in a considerable number of cases and there were isolated infestations of the saw-toothed grain beetle and the foreign grain beetle, *Ahasverus advena* (Waltl.). House moths, *Endrosis lacteella* (Schiff.) and *Hofmannophila pseudospretella* (Staint.) were among the insects most frequently found in grain elevators at Vancouver, New Westminster, and Victoria, B.C.

A survey of insects associated with farm-stored wheat was made in three samplings four months apart (November, 1953; March and July, 1954) on 90 farms located in three areas of Alberta and Saskatchewan. Samples were taken from old and new wheat stored in granaries, open piles, granary spills, and on the ground; and from residues on walls of granaries, floors of sheds, machine shops, and elsewhere. Approximately 10,000 insects and mites were collected

during the survey. The largest numbers were collected in the summer sampling, the smallest in the spring (March). Mites were most frequently collected. Fungus beetles (Lathridiidae, Cryptophagidae) and rove beetles (Staphylinidae) made up the Coleoptera most commonly found. The rusty grain beetle, the most serious pest of prairie grain stocks, was found distributed in all areas. A considerable proportion of the 1954 wheat crop was threshed under unfavourable weather conditions and it is likely that there will be insect problems with at least part of this material.

Serious insect infestations involving the Indian-meal moth were found in certain of the elevators in Eastern Canada, particularly in Halifax, Midland, Owen Sound, and Sarnia. The granary weevil and rice weevil infested 300,000 bus. of grain in elevators at Montreal, Que.

MILL AND FEED WAREHOUSE INSECTS.— The confused flour beetle and the flat grain beetle continued to be the most troublesome pests in flour mills throughout Canada. In some of the smaller mills the Mediterranean flour moth was also of considerable importance. On the Prairies the hairy spider beetle was present in considerable numbers in flour warehouses and on the surface of wheat stored in granaries in the Aberleen-Colonsay-Young district in Saskatchewan. The yellow mealworm infested a mill at Winnipeg, Man., and *Cynaeus angustus* (Lec.) occurred in a flour mill at Medicine Hat, Alta. The Australian spider beetle *Ptinus ocellus* Brown was the most important warehouse pests on the Pacific Coast. There were also several infestations of *Endrosis lacteella* (Schiff.), *Hofmannophila pseudospretella* (Staint.), and *Aphomia gularis* Zell., in warehouses in the Vancouver area. The varied carpet beetle and the Mediterranean flour moth occurred in large numbers in flour mills and cereal warehouses in Vancouver. The black carpet beetle was the most common beetle in these storages in the interior of the Province.

BEAN WEEVIL.— This insect was reported from Langley Prairie, B.C.; Winnipeg; Man.; and several points in Ontario and Quebec.

CIGARETTE BEETLE.— Reported infestations included wheat in elevator sample boxes at Medicine Hat, Alta,; paprika in a dwelling in Winnipeg, Man. (possibly the first record in the Province), and outbreaks in several tobacco warehouses in Montreal, Que.

FLOUR BEETLES.— Infestations of the confused flour beetle occurred commonly in stored cereals in dwellings in the Prairie Provinces, and in northern Alberta *Tribolium destructor* Uytten was reported to be increasing and almost as common as *T. confusum* Duv.

ODD BEETLE.— An adult was taken in the University of Alberta.

SAW-TOOTHED GRAIN BEETLE.— This insect was reported from Kamloops, B.C., Winnipeg and Flin Flon, Man.; several points in Ontario; and Berthierville, Que. Several infestations occurred in dwellings at Flin Flon. Reports were somewhat less numerous than usual in Ontario.

MISCELLANEOUS.— An unusual infestation of the Mediterranean flour moth occurred in a hay mow near Ottawa, Ont. The pest was present in extremely large numbers, yet there was no trace of cereal material, the normal food of this pest. A large number of cocoons of a Chrysopid (aphis lion) were found in a granary at Lake Alma, Sask., presumably the result of mature larvae on the grain being binned with the wheat at harvest time and subsequently pupating. Infestations of the larder beetle occurred in stored grain at Walrous and Brock, Sask. A sample of newly-threshed grain from Portage la Prairie contained many case-bearing larvae (Coleophoridae). They were apparently feeding on some weed in the field and had been picked up in harvesting and passed through with the barley into the grain bin. Larvae of a syrphid, *Syritta pipiens* (L.), were found in ensilage on Feb. 22 at Selkirk, Man. Adults emerged at the University of Manitoba in March from samples received.

NOTES ON SOME NEMATODE OCCURRENCES

The golden nematode, *Heterodera rostochiensis* (Wollenweber, 1923) Franklin, 1940, has not yet been found in any part of Canada. The sugar-beet nematode, *Heterodera schachtii* Schmidt, 1871, did not occasion any severe injury in sugar-beet fields of the Sarnia, Ont., area in 1954.

The oat nematode, *Heterodera avenae* (Lind, Rostrup, and Ravu, 1913) Filipjev, 1934, continued to be a pest of importance in central Ontario. *Heterodera punctata* Thorne, 1948, was named and described from infested wheat in western Canada. The northern root-knot nematode *Meloidogyne hapla* Chitwood, 1949, was found on the roots of *Fragaria vesca* at Kentville, N.S.; on carrot from Thedford Marsh, Ont.; and on African violet roots at Ottawa.

Records of infestastations of root-lesion nematodes included *Pratylenchus penetrans* (Cobb, 1917) Sher and Allen, 1953, from *Fragaria vesca* roots at Kentville, N.S.; daffodil bulbs and tulip roots from Vancouver, B.C.; nursery soil from Port Burwell, Ont.; red clover roots and soil from Merivale, Ont.; African violet roots and soil at Ottawa, maple tree roots from Ottawa, and apple tree roots from the Okanagan Valley, B.C. *Pratylenchus minyus* Sher and Allen, 1953, was found attacking corn at Ottawa; oats at Uxbridge, Hampton, and Port Perry, Ont.; barley and cultivated and wild oats at Aurora, Ont.; and wheat at Harrow, Ont. *Pratylenchus pratensis* (deMan, 1880) Thorne, 1949, was found in strawberry roots from Stanstead, P.Q., and from Fredericton, N.B.; oat roots from Merivale, Ont.; and *Fragaria vesca* roots from Kentville, N.S. *Pratylenchus vulnus* Allen and Jensen, 1951, was obtained from rose roots being grown in a greenhouse at Mount Bruno, P.Q.

Ring nematodes, *Criconemoides* spp., were found in strawberry soil in Fredericton, N.B., and Stanstead, P.Q.; rose roots in a greenhouse at Mount Bruno, P.Q.; maple tree soil and vetch soil at Ottawa; and in soil from the roots of *Fragaria vesca* from Kentville, N.S.

Although occasional new records of the potato-rot nematode, *Ditylenchus destructor* Thorne, 1945, were obtained from Prince Edward Island, there was no clear evidence that the total infestation had become greater.

Other plant-parasitic nematodes encountered included spiral nematodes, *Rotylenchus*, spp., from Kentville, N.S.; Fredericton, N.B.; Merivale, Sarnia, and Ottawa, Ont. *Psilenchus hilarulus* de Man, 1921, was found in grass sod at Ottawa, Ont.; *Hemicycliophora* sp. in tulip soil from Walkerville, Ont.; stunt nematodes, *Tylenchorhynchus* sp., in oat soil from Preston and Merivale, Ont. Pin nematode, *Paratylenchus* sp., was reported on apple from Okanagan Valley, B.C.; in oat soil at Merivale, Ont.; maple tree soil from Ottawa, and tulip soil from Walkerville, Ont. Dagger nematodes, *Xiphinema* sp., were found in tuberous begonia soil from Sarnia, Ont., and soil from maple at Ottawa. A grass nematode, *Anguina agrostis* (Steinbuch, 1799) Filipjev, 1936, was found in the heads of *Poa pratensis* from Cornwall, Ont.

The foliar nematode, *Aphelenchoides ritzema-bosi* (Schwartz, 1911) Steiner, 1932, was found in chrysanthemum leaves from St. Catharines, Ont. *Aphelenchoides parietinus* (Bastian, 1865) Steiner, 1932, was found in potato tubers from Prince Edward Island; narcissus bulbs from Montreal; strawberry soil from Fredericton, N.B.; lesions on chrysanthemum roots from St. Catharines, Ont.; and shasta daisy from London, Ont. *Aphelenchoides avenae* Bastian, 1865, was found in oat soil from Aurora and Merivale, Ont.; shasta daisy from London, Ont.; lesions on chrysanthemum roots from St. Catharines, Ont.; narcissus bulbs from Beaurepaire, Que.; adjacent to peony roots from Ayers Cliff, Que.; potato tubers from Prince Edward Island, and apple from Okanagan Valley, B.C.

A number of new records of predacious nematodes belonging to the genus *Mononchus* were obtained. *Mononchus brachyuris* (Bütschli, 1873) Cobb, 1917, was found in soil around begonia roots at Sarnia, Ont.; lawn soil from Capreol, Ont.; oat soil from Belleville, Ont.; and ditch soil from Blackwell, Ont. *Mononchus longicaudatus* (Cobb, 1893) Cobb, 1916, was found in ditch soil at Blackwell, Ont.; and *Mononchus muscorum* (Duj., 1845) Cobb, 1916, in grass sod from Blackwell, Ont.; meadow sod from Norton, N.B.; mountain soil from "Summit", Princeton, B.C.; and streamside soil from Hope, B.C. *Mononchus papillatus* (Bastian, 1865) Cobb, 1916, was found in lake shore sod from Sunnydale, Ogden County, Que.; and from grass sod at York, P.E.I. *Mononchus parabrachyuris* Thorne, 1924, was identified from ditch soil from Blackwell, Ont., and *Mononchus parvus* (deMan, 1880) Cobb, 1916, in tobacco soil at Harrow, Ont.; and in tulip bed soil from Walkerville, Ont.

PROCEEDINGS OF THE NINETY-FIRST ANNUAL MEETING ENTOMOLOGICAL SOCIETY OF ONTARIO

The 91st Annual Meeting of the Entomological Society of Ontario and the 4th Annual Meeting of the Entomological Society of Canada, were held jointly at Sault Ste. Marie, Ontario, on November 1—3, 1954.

On Sunday afternoon the Forest Insect Laboratory held an Open House and Tea from 2—5 p.m.

The meetings opened at 10:00 a.m. on Monday in the Armoury Theatre. Professor A. W. Baker, President of the Canadian Society, acted as chairman of the opening session. Dr. Belyea of the Forest Insect Laboratory welcomed the members and friends of the Societies to Sault Ste. Marie and Dr. Beirne, Acting President, extended a welcome on behalf of the Ontario Society as host of the joint meetings.

The following invitation papers were presented: Dr. A. J. Cipriani, Atomic Energy of Canada Ltd. on "Insects and Radiation". Dr. E. M. Walker, Professor Emeritus of the Department of Zoology, University of Toronto on "Changes in the Native Insect Fauna of Southwestern Ontario in Fifty Years, apparently Associated with Climatic Changes"; Dr. C. E. Mickel, Department of Entomology and Zoology, University of Minnesota, on "The Historical Development of Insect Classification"; and Dr. J. H. Pepper, Department of Entomology and Zoology, Montana State College, on "Genetics and Physiological Adaptations of Insects to the Environment."

A symposium on the general subject of "Approaches to the Study of Forest Insects with special reference to the Larch sawfly, *Pristiphora erichsonii* (Htg.)" was presented. Contributions were given by H. C. Coppel, R. R. Lejeune, J. A. Muldrew, F. T. Bird and S. G. Smith. The moderator was R. E. Balch.

Forty-four submitted papers were presented on Tuesday morning to four sectional meetings: Insect Physiology (A. S. West, Chairman), Natural Control and Ecology (W. E. Heming, Chairman), Insecticides and Acaricides (H. Martin, Chairman), and Taxonomy and General Entomology (O. Fournier, Chairman).

The Annual Banquet was held on Tuesday evening in the Windsor Hotel. Dr. S. G. Smith, Chairman of the Local Committee acted as Master of Ceremonies. Colonel Harry S. Hamilton, Q. C. addressed the gathering on "To Build a Better Democracy".

The business meeting of the Society was held on Wednesday morning. The report of the Secretary-Treasurer for 1954 was read and approved. In keeping with the Constitution, it was decided that the Annual Meeting in 1955 would be held at the Ontario Agricultural College, Guelph, on October 31, November 1 and 2.

The following reports were presented and adopted:

REPORT OF THE NOMINATIONS COMMITTEE[1]

The following members are proposed as officers of the Entomological Society of Ontario for 1955: B. P. Beirne, R. M. Belyea, A. W. A. Brown, G. F. Manson, J. A. Oakley, R. H. Ozburn, and A. S. West. For Auditors for the same period: R. C. Cooke and C. J. Payton — Province of Ontario Savings Bank, Guelph.

Respectfully submitted,

J. McB. Cameron, H. Coppel,
G. G. Dustan, *Chairman.*

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[1]W. C. Allan will serve as Secretary-Treasurer and Librarian.
W. E. Heming will continue as Editor of the Annual Report.

REPORT OF THE RESOLUTIONS COMMITTEES

Be it resolved that:

The Chairman of the Local Committee forward a letter of appreciation to Mr. D. S. Holbrook, Vice-President of Algoma Steel Corporation for making available to the President of the Entomological Society of Canada and his wife, through the local members, Sir James Dunn's suite in the Windsor Hotel.

That the Secretary forward a letter to Lt. Col. E. G. Vance, Officer Commanding, 49th (SSM) H.A.A. Regt. R. C. A. thanking him for his kind permission to hold the joint meetings of the two societies in the Sault Ste. Marie Armoury, thereby contributing in large measure to the success of the gathering.

That the Secretary forward letters of appreciation to the Officers-in-Charge of the Forest Insect Laboratory and the Laboratory of Insect Pathology for providing the members with the privilege of visiting these laboratories.

That the Entomological Society of Ontario hereby express its appreciation for the contributions made to the Local Committee by the organizations listed in the programme.

That the Chairman of the Local Committee and the Secretary of the Ontario Society extend the appreciation of the members to the O'Keefe Brewing Co. Ltd., and the Canadian Wine Institute for their assistance in the entertainment of the members and guests.

That the Chairman of the Local Committee and the Secretary of the Ontario Society convey the appreciation of the members to the local press (Sault Star) and the local radio station (CJIC) for the excellent publicity given to the meetings.

That the Entomological Society of Ontario express its appreciation to the Local Committee for the excellent arrangements made for the meetings.

Respectfully submitted,

S. G. Smith, L. L. Miller,
W. Baldwin, *Chairman*

The members and guests in attendance at the meetings numbered 191. Seven states were represented and all of the ten provinces.

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Insects

ANNUAL REPORT
of the
ENTOMOLOGICAL SOCIETY OF ONTARIO

Volume Eighty-Six

1955

PUBLISHED BY AUTHORITY OF
THE HONOURABLE WILLIAM A. GOODFELLOW, MINISTER OF AGRICULTURE FOR ONTARIO

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ANNUAL REPORT
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HONOURABLE WILLIAM A. GOODFELLOW

Minister of Agriculture for Ontario

EDITED BY: A. J. MUSGRAVE

World List of Scientific Periodicals
Official Abbreviation: Rep. ent. Soc. Ont.

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The Ninety-Second Annual Meeting of the Entomological Society of Ontario was held at the Ontario Agricultural College, Guelph, Canada on October 31, November 1 and 2, 1955.

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NUTRITIONAL REQUIREMENTS AND ARTIFICIAL DIETS FOR INSECTS

Chairman: G. F. Manson *Co-ordinator:* H. L. House

Panel: K. R. Elliott
W. G. Friend
H. L. House
K. R. P. Singh
H. G. Wressell

INTRODUCTORY REMARKS[1]

H. L. House[2]
Entomology Laboratory, Belleville, Ontario

The food requirements and nutrition of insects should interest every entomologist because the injury done by insects is the result of their efforts to obtain food. The study of nutrition is that section of physiological science that deals with the sum of the processes by which a living organism absorbs, or takes in, and utilizes food substances. Knowledge of nutrition is basic for studies on the vital processes and the various functions that occur within the insect. Entomologists learn much about the phenomena of insect life by the study of nutrition, as what an insect eats has far-reaching effects on its behaviour and its feeding habits usually determine its economic importance. To recast a trite statement, "An insect is what it eats". Insects, possibly more than any other class of animal, are unusually diverse in feeding habits, nourish themselves from an almost endless variety of foodstuffs, and may even have made remarkable adaptations to subsist. These facts have stimulated entomologists to investigate the food and nutritional requirements of many insects. Brues (6) has published an extensive discussion on the foods of insects.

Almost all terrestrial and fresh water plants and animals, or their waste products, or their decomposing bodies, ultimately provide food for insects; usually there is at least one species of insect associated with each organism, requiring all or part of it as food in order to exist, grow, and reproduce. The food and feeding habits of the immature stages and the adult are often very different. Though a number of species eat almost anything organic, most have more restricted diets and may even show marked discrimination in their choice of food. Some species have a high specificity for certain kinds of food. The reasons for this are not fully understood. The dependence of the silkworm, *Bombyx mori* (L.), on mulberry leaves and of the boll weevil, *Anthonomus grandis* Boh., on cotton bolls are notable examples of food specificity. Some species became pests when they adopted new sources of food. For example, the Colorado potato beetle, *Leptinotarsus decemlineata* (Say) ,left its native food plant for potato. The Mexican bean beetle, *Epilachna varivestis* Muls., became a pest on legumes though closely related species are predatory on aphids and coccids. Some insects, such as the honey bee, even manufacture special foods from raw materials collected in the field and these foods may have marked effects on the form and development of the insects. Dietary factors influence and probably determine polymorphism in aphids and in some other insects, possibly including ants and termites, and probably determine dimorphism in honey bees. These examples demonstrate that nutritional physiology of insects is a complex subject.

[1]Contribution No. 3415, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada; presented at the 92nd Annual Meeting of the Entomological Society of Ontario, Guelph, October 31—November 2, 1955.
[2]Senior Entomologist.

Research on insect nutrition has passed through a transition phase from a descriptive naturalist or qualitative stage to a more fundamental or quantitative stage. Uvarov's (31) review of insect nutrition, published in 1929, showed that much of the work up to then consisted of observations on the growth of insects on various foodstuffs that are more or less accessible to the insect in nature. Many of the earlier workers made heuristic investigations that later led to the identification of growth requirements of a few representative species. Much valuable preliminary work is still done by these methods of investigation. The complexity of natural foodstuffs, such as a growing plant or animal, limits their usefulness in the precise determination of the essential ingredients required by the insect. Much of this difficulty has been overcome during the last decade by the use of highly purified, chemically definable, synthetic diets. These synthetic foods can be altered in composition for almost any purpose; hence their popularity in fundamental nutritional studies is increasing. A further refinement in technique is to rear the insect in sterile cultures to avoid the intervention of symbiotic microorganisms that might alter the nutritive composition of the diet. *Drosophila melanogaster* Mg. was the first multicellular organism to be reared on a chemically defined medium in the absence of microorganisms (27) and an increasing number of other insects have been so reared since. Despite the variety of the methods used by various workers, data on the nutritional requirements of insects are being pieced together. Reviews of the literature have been published by Uvarov (31), Wigglesworth (32), Craig and Hoskins (7), Trager (28-30), Levinson (23), and others, and a summary of the data published by a number of workers has been prepared in tabular form (1).

The dietary requirements of insects, like those of other invertebrates, are remarkably similar to those of mammals. Though insects require relatively complex molecules such as sterols (12) on the one hand, they can incorporate simple inorganic ions such as sulphur (17) into essential amino acids on the other. Apparently they require the same amino acids as mammals and birds, yet they require only vitamins of the water-soluble B complex, not the fat-soluble vitamins A, D, E, and K or the water-soluble vitamin C. All insects require a variety of inorganic salts and most insects utilize carbohydrates and fats. Ribonucleic acid or its purine and pyrimidine bases improve the growth of most insects that have been investigated. Other accessory growth factors have been identified and have been shown to have more or less limited effects on certain species. Hence the dietary requirements of an insect for growth to maturity include: the amino acids that are also essential to the rat and the chick; cholestelol or ergosterol; a number of inorganic salts, including phosphorus, potassium, calcium, and magnesium; a carbohydrate such as starch, sucrose, or dextrose; a number of vitamins of the B complex, including thiamine, niacin, riboflavin, and others commonly in vitamin supplements for human use; water; usually ribonucleic acid or fractions of it; possibly a fat; and perhaps a few miscellaneous factors yet to be identified. Insects can convert carbohydrates and proteins into fats as well as synthesize a number of necessary factors, which consequently are not required in their diet. These synthesized substances usually are not included among the nutritional requirements of the insect; however, they probably should not be so easily dismissed as they are nutrients that are necessary to complete the nutritional complex of the insect.

There are, however, notable differences between the dietary requirements of insects and mammals. Insects, but not mammals, require sterols and some purine or pyrimidine fraction of ribonucleic acid; and mammals, but not insects, usually require vitamin C and the fat-soluble vitamins. Apparently insects lost, or never had, the power to synthesize some of these substances, which mammals synthesize efficiently. Insects presumably need vitamins of the B complex, for these vitamins play similar roles in the metabolic enzyme systems of insects and of mammals. One may speculate that insects do not need vitamin D, the anti-rachitic vitamin, for they have no calcified bony skeleton. However, insects require cholesterol or ergosterol, which are closely related chemically to vitamin D. Among other roles, vitamin A is concerned with optimum vision in mammals, but insects apparently have different mechanisms or substitute other substances, for neither vitamin A nor its precursors are utilized by them.

No important differences that have a taxonomic significance have been found in studies on the nutritional requirements of insects. Representative species of a number of genera, largely of Orthoptera, Coleoptera, Lepidoptera, Diptera, and Hymenoptera and to a lesser extent of Homoptera and Siphonoptera, have been investigated (1). These include insects that feed on a wide variety of foods and that have very different feeding habits, including the dipterous parasite *Pseudosarcophaga affinis* (Fall.) (18-21). It is true that the necessity for some substances may differ between species; for example, all insects do not need the B vitamin pyridoxine. Some insects feed on foods rich in certain microorganisms or have a rich intestinal fauna and flora and may at first glance appear to have few dietary requirements. However, many microorganisms manufacture a variety of nutrients (9) and when these organisms are eliminated it is found that the insect has more extensive requirements, similar to those of other species (25).

This raises the question of a universal diet for insects. It may not be an over-simplification of the dietary problem to suggest that from a number of nutritive entities in the simplest molecular or ionic form in which they are absorbed a synthetic food could be developed to satisfy the requirements for approximately optimum growth in any insect. Such a diet would circumvent most of the digestive enzyme complex. Allowance could be made for nutritional similarities and differences among species. A "universal" food medium was developed by Luckey (24) to rear six different kinds of microorganisms, monkeys, pigs, cats, dogs, mice, rabbits, an opossum, guinea pigs, chicks, goldfish, cockroaches, snails, and tomato plants. Fraenkel and his co-workers reared a number of different insects (12, 14, 15) on a diet developed for *Tribolium confusum* Duv. Hence the elements essential for adequate nutrition are remarkably similar for many species. Therefore, there is good reason to expect that most insects could be grown on a diet consisting of about 30 essential nutrients in their simplest forms. Such a diet would probably include at least a dozen amino acids, dextrose, cholesterol, some purines and pyrimidines of ribonucleic acid, a mixture of inorganic salts, fatty acids, eight or more B vitamins, and water. It would be necessary to vary the concentrations of these nutrients to prevent their reaching toxic levels. Also, the physical form of the diet would have to be changed to satisfy the feeding habits of many species; it might need to be in a dry granular form for roaches and for insects that feed on stored products and in a liquid solution for insects such as mosquitoes or aphids. Technical difficulties would probably be more formidable than nutritional problems. Very ingenious techniques would have to be devised to induce some species to feed, and some of the highly specialized parasitic species would be extremely difficult to satisfy. Factors other than nutrients that are essential for sustaining life may determine the suitability of food. These include responses to optical, auditory, tactile, and chemotactic stimuli, chemical stimuli being both olfactory and gustatory. There is no evidence, however, that the chemical substances with characteristic odours and tastes that are responsible for the selection of specific foods play any part as essential nutrients.

The investigation of the nutritional requirements of insects, however, is far from complete. Little is known about the requirements of some important groups such as the phytophagous species and those parasitic on insects. However, some fundamental work has been done on these groups by Bottger (4, 5) and Beck, Lilly, and Stauffer (3), on the European corn borer, *Pyrausta nubialis* (Hbn.); by Friend (16), on the onion maggot, *Hylemya antiqua* (Mg.); and by Ishii and Hirano (22), on the Asiatic rice borer, *Chilo simplex* (Butl.). House (18-21) determined for the first time the nutritional requirements of an entomophagous parasite. Another highly specialized insect, the honey bee, *Apis mellifera* L., has been studied recently (8). Little work has been done on the definition of the requirements for reproduction. New nutritional factors are continually being discovered (9) and the roles of other nutrients are becoming increasingly better understood. Nutrition is a chemical process and its principles must be presented in chemical terms. When sufficient evidence is obtained on these complex processes, the solution to many of the mysteries that confront the biologist, the physiologist, and the chemist will be clearer.

Studies on the nutrition and dietary requirements of insects have benefited many fields of biology. It was during studies in medicine on growth processes in connection with cancer

that Schultz (27) and his co-workers developed a chemically definable diet for *D. melanogaster* and used the technique to determine the effects of nutrients on tissue growth and cellular metabolism. Nutritional studies may eventually throw light on the pathways of nutritional evolution and complement the work being done in comparative biochemistry and morphology. Experimental diets that may result from nutritional studies will eliminate food as a complex variable in genetic, physiological, and toxicological studies. There is promise that nutritional studies in agriculture will shed more light on plant protection. Pepper and Hastings (26) suggested that the beet webworm, *Loxostege sticticalis* (L), thrives best on varieties of its host plant that are richest in linoleic acid, a fatty acid. Fraenkel (11) attempted to correlate the nutritive content of various plants with the requirements of insects. Auclair and Maltais (2) also pointed out differences in the amino acid content of pea varieties that differ in susceptibility to aphid attack. It is not surprising, therefore, that interest in insect nutrition is increasing. The study is becoming more specialized and is developing its own distinctive experimental methods, some of which will be outlined by the other speakers in this symposium.

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REARING THE EUROPEAN CORN BORER, *PYRAUSTA NUBILALIS* (HBN.) (LEPIDOPTERA: PYRALIDIDAE), ON AN ARTIFICIAL DIET[1]

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The interest in an artificial diet for the European corn borer, *Pyrausta nubilalis* (Hbn.), at the Chatham laboratory is an outgrowth of other work on this insect. The borer is reared at Chatham in winter in studies on diapause and also in studies on differences between the univoltine and multivoltine strains of borer. In these studies it is impractical to observe the larvae in corn grown in the greenhouse, and rearing them on other natural food, such as fresh string beans, is time-consuming.

METHODS OF OTHER WORKERS

Bottger (6) in 1937 initiated studies on finding chemical substances in the green plant that are associated with the survival, growth, and metamorphosis of the corn borer. As a result of these studies he (7) developed a prepared diet for use in nutrition studies on the borer.

Bottger's findings were later utilized by Beck and his co-workers (1-3) at the University of Wisconsin in their studies on the nutritive requirements of the borer. The methods developed by these workers, especially Beck, are important to the insect nutritionist, the economic entomologist, and the insect physiologist in showing that a chewing, phytophagous insect can be reared on a prepared diet. This diet (3), which has become known as "Beck's diet", originated as a result of a study (2) in which differences in larval mortality were noted when borers were reared on two sources of corn—a susceptible corn hybrid and a resistant corn hybrid—A brief review of Beck's work is given to clarify the discussion that follows.

Beck, employing methods similar to those used by Swingle (8) in his study of the oriental fruit fly, studied the enzymes present in the digestive tract of the borer. He established that the larvae utilized fats, proteins, and at least the disaccharide sucrose in their diet. Beck used this information to develop a purified diet for rearing the borer. The diet allowed growth to maturity (pupation or diapause), with apparently normal moths resulting. Beck did, however, have some difficulty in obtaining a satisfactory vitamin complement. At first brewer's-yeast powder was used as the source of vitamin B, but later this was replaced by a vitamin B complex. The diet used at Chatham was Beck's improved version of the original diet. The composition of the improved diet is given in Tables 1 and 2.

According to Beck the key to this diet was an unidentified corn leaf factor; variations in the amounts of this factor resulted in abnormalities in larvae, pupae, and emerging moths. Consequently, he conducted a number of experiments to find the cause of these abnormalities, and to discover more about the unidentified factor (4, 5).

Besides being found in corn leaves, the unidentified factor has been expressed in the juice of other grasses and it is present in varying amounts in a number of other plants. It is, according to Beck (5), heat-soluble, acid-stable, water-soluble, and dialyzable. The unidentified factor does not appear to be identical with any of the known B vitamins, or with ascorbic acid, sodium nucleate, citrovorum factor, or carnitine.

Beck found that "Dietary levels of leaf concentrate greater than 8 per cent tended to inhibit borer development". He also found that the females required a much higher level of

[1]Contribution No. 3413, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada; presented at the annual meeting of the Entomological Society of Ontario, Guelph, October 31-November 2, 1955.

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corn leaf factor than did the males. There is great variation, too, in the results produced by the concentrate itself, depending on the source. Except for ground corn leaves, a grass juice extract known as SBJ (Cerophyl Laboratories Inc., Kansas City, Mo.) gave the best results.

Table 1

Composition of the basic purified diet used in nutritional studies on the European corn borer (Beck, 5)

Function	*Substance*	*Amount used (gm.)*	*Dry diet (per cent)*
	Distilled water	125.00 (ml.)	0.0
Carrier	Bacto-agar	3.350	14.5
	Cellulose (fibrous)	2.750	12.0
Carbohydrate	Glucose	7.600	33.0
Protein	Casein	6.400	27.8
	Cholesterol	0.230	1.0
Lipids	Corn oil containing 1 per cent tocopherol	0.230	1.0
Minerals	Wesson's salts	0.460	2.0
Vitamins	Vitamin B complex (Table 2)	0.075	0.4
	Choline chloride	0.065	0.3
Unknown factor (s)	Leaf sap concentrate	1.840	8.0
		23.000	100.0

Table 2

Vitamin	*Amount, per gm. dry weight* Mg.
Choline	1000
Thiamine HCl	12
Riboflavin	18
Nicotinic acid	100
Ca pantothenate	40
Pyridoxine HCl	16
Inositol	2000
p-Aminobenzoic acid	50
Folic acid	5
Biotin	1

STUDIES AT CHATHAM

Studies were initiated at Chatham, in 1950, on factors in the change from a univoltine to a multivoltine strain of borer. For nearly 20 years only one generation a year of the borer had been found in southern Ontario, but by 1945 it was evident that multivoltinism had appeared (9). Studies on diapause in this species are also being conducted. During the earlier stages of this work the natural food plant, corn, was used during the winter months for rearing the borers. This was impractical, mainly because the growth of the borer could not be observed, and it was difficult to have the plants at the proper stage for larval establishment when necessary. Fresh green string beans have always been highly regarded for mass rearing of the borer in the laboratory, but this food is not satisfactory for the present studies. The

cells in the bean pod break down quickly and spoilage results; this means that the food must be changed frequently to prevent high mortality among borers because of eating contaminated food. Consequently, the larvae are handled frequently, the mortality is high, and the method is very time-consuming. On Beck's diet the larvae could be reared separately in glass vials and feeding could continue for 10 days or longer before it was necessary to renew the food, so that contamination of the media was less likely.

Soon after Beck's improved diet was reported, it was used at Chatham, methyl-p-hydroxy-benzoate, a mould inhibitor, being added. In preparing the medium either a Waring blender or a Dormeyer food mixer was used; thus a thorough mixing of materials was possible. The medium was then sterilized in a Presto food cooker at either 17 pounds' pressure for 5 minutes or 15 pounds pressure for 10 minutes. The medium was then placed in sterilized 1-dram shell vials, which were plugged with absorbent cotton. A single larva was placed in a vial of medium and allowed to feed unmolested.

The following progress toward rearing pure lines of multivoltine stock has been made. Eggs of multivoltine stock from Poughkeepsie, N.Y., were obtained at the end of June, 1955. These were placed on the medium in the black-head stage and allowed to develop. Pupae were obtained within 18 days. From these pupae moths emerged and laid second-generation eggs, all of which were viable. The second, or F1, generation developed in about the same time as the parental stock, but about 40 per cent entered diapause, and a number of emerging moths were small and weak. Some of the F2 eggs were infertile, but a number of larvae hatched and were reared on the medium. Mortality in the early instars of the F2 generation was high, and some moths upon emerging failed to inflate their wings. However, again a number of viable eggs were produced and an F3 generation of larvae fed on the medium. Moths that emerged from this generation, however, were infertile; they laid only a few, inviable eggs.

That the diet is deficient was suggested by the results obtained on a diet of string beans. At the time the eggs were brought from Poughkeepsie, a number of the newly hatched larvae were placed on string beans. Five generations were reared on this material before there was any noticeable loss of vigour, and moths of the F5 generation laid viable eggs.

The development of a suitable artificial diet would be of great value to the field entomologist. If the unidentified corn leaf factor should be isolated, the lack of vigour in the larvae might be overcome.

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PROBLEMS IN NUTRITIONAL STUDIES ON PHYTOPHAGOUS INSECTS[1]

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INTRODUCTION

The nutrition of plant-feeding insects has not been studied with much success until recently. In this paper, the author outlines the difficulties that must be solved before the nutritional requirements of a phytophagous insect can be determined. Many of these remarks apply also to research on non-phytophagous forms.

To do the best work in nutrition one should use chemically defined diets under aseptic conditions. Without a diet of which the chemical content is completely known, quantitatively and qualitatively, one can never be sure that the nutritional effect he wishes to study is isolated from unknown factors in the diet. Microorganisms must be excluded because they can, through metabolic processes, produce almost every known dietary factor, consequently ruining the significance of the nutritional test. The problems then are these: (a) To formulate a mixture of chemicals that will allow a phytophagous insect to grow normally under aseptic conditions. (b) To devise methods of rendering both diets and insects aseptic. (c) To select some appropriate criterion of growth for measuring the effects of the diets.

FORMULATION OF CHEMICALLY DEFINED DIETS

Formulating a suitable chemically defined diet for a plant-feeding insect is the most difficult problem to be solved. Most phytophagous insects have distinctive food habits under field conditions. Some species, such as *Bombyx mori* (L), are restricted to one host plant. Other insects, such as locusts, feed on many species of plants although their development on different species varies considerably (12, 13). Over the ages, the processes of evolution have produced very close links between many plant-feeding insects and their foods.

The chemically defined diet should fulfil the following requirements: (i) It must satisfy the insect's micro-ecological requirements of tactile and chemical attractiveness, and must be in a satisfactory physical form. (ii) It must contain the correct amounts of the nutritional elements needed for normal development.

Micro-ecological Requirements

At present, little is known about the factors that determine tactile attractivness. Maltais (11) has briefly reviewed the requirements for a membrane through which aphids can feed. It has been observed by officers at the Ottawa laboratory that very pubescent potatoes form a mechanical barrier to young larvae of the Colorado potato beetle. There are other scattered records in the literature but the author has been unable to find a comprehensive review of this subject. The problem of creating an acceptable feeding surface is difficult. A great many attempts to rear external leaf feeders on chemical diets have failed because the young

[1]Contribution No. 3403, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada; presented at the 92nd annual meeting of the Entomological Society of Ontario, Guelph, October 31, 1955.

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larvae could not adapt their feeding habits to cope with an unnatural feeding surface. No one has yet been able to make a diet that approximates the physical form of leaf closely enough to be useful. Slicing agar-based diets with a corrugated vegetable slicer, and piling the corrugated slices crossways so that the maximum amount of diet surface is exposed, is one method that has been used successfully. Slicing the media into thin sheets and hanging them in sterile glass cages has also been tried; but the thin slices dry rapidly and the method is very time-consuming.

Not much that is useful to the nutritionist is known about the chemical attractiveness of plants to insects. Thorsteinson (16) has reviewed work on the chemotactic basis of host specificity in phytophagous insects. He states that in 1905 Grevillius found that larvae of the brown-tail moth, *Nygmia phaeorrhoea* (Donov.), which feeds on chickweed, *Stellaria* sp., could be induced to feed on other plants if their leaves were smeared with a paste containing tannin from chickweed. Although the test preparations were not chemically pure, obviously the feeding of the larvae indicated that the test material contained some substance that stimulated their appetite. In 1910 Verschaffelt (17) observed that all plants acceptable as hosts by larvae of the butterflies *Pieris rapae* (L.) and *Pieris brassicae* (L.) contained mustard-oil glycosides. His experimental techniques, however, did not permit a complete analysis of the various factors involved.

In 1952, Chauvin (3) investigated the feeding stimulant of the Colorado potato beetle, *Leptinotorsa decemlineata* (Say), an oligophagous insect restricted in host range to the genus *Solanum* and a few other plants. He found that the feeding stimulant gave reactions characteristic of the flavone glucosides. Hess and Meier (6), studying the same insect, found that both larvae and adults could be induced to feed upon blocks of gelatin that had been treated with acetaldephyde.

Thorsteinson (15) has shown that the chemotactic basis of host specificity for *Plutella maculipennis* (Curt.) is the presence of the chemical sinigrin, a mustard-oil glycoside. The presence of a mustard oil, allyl isothiocyanate, enhhanced the feeding response with this species. Alder pith was used during these experiments as a suitable mechanical support for the chemical extracts.

These findings are too limited to be very helpful to the worker who is attempting to create an acceptable chemically defined diet. One possible solution to the problem is to make extracts of the host plant, determine the attractive agents, and add them to the diet. To the author's knowledge, no one has ever completed this process successfully. Many diets that appeared to contain the correct nutritional chemicals have been useless because the insects refused to eat them, apparently because of the absence of the proper chemical attractants.

Nutritional Requirements

If the test insect eats the artificial diet, there is still the problem of finding the nutritional elements needed for normal growth, and the correct concentration of each of these elements. The obvious approach is to obtain an accurate chemical analysis of the plant tissue that constitutes the insect's normal food and to duplicate the food by using pure chemicals. This approach, although logical, has not yet been used successfully. At present, chemical, techniques have not been devised for analyzing plants with sufficient thoroughness. Beck (2) has shown that there are one or more unidentified dietary factors required for the normal growth and maturation of the European corn borer, *Pyrausta nubilalis* (Hbn.). These dietary elements, which Beck has termed "the corn leaf factor", are found in corn and grass leaves. Whether most plant-feeding insects have similar needs for compounds that are not yet considered as nutrients remains to be seen.

Another method of formulating a suitable diet is to fractionate the food plant by chemical treatment, and, for example, to remove all of the vitamins and replace this fraction of the diet with mixtures of pure vitamins. This method fails because of the lack of dependable chemical techniques.

The only method that has so far been successful is empirical. One collects as much information as possible about the chemical constituents of the natural food of the test insect, examines the insects' feeding habits under natural conditions, learns the composition of chemical diets that have been successful with similar insects, formulates a diet based on these findings, and tests it. The procedure is tedious, but until more is known about the nutrition of plant-feeding insects a more direct one cannot be found. Using this method, the author (4) has developed a mixture of 44 chemical consisting of 19 l-amino acids, nine crystalline B vitamins, coenzyme A, thioctic acid, inosine, thymine, ribonucleic acid, glucose, cholesterol, U.S.P. XIII salt mixture, and agar; with this, the onion maggot, *Hylemya antiqua* (Mg.), can be reared from egg to adult aseptically and individually in one-dram, screw-capped vials. When the adults are removed from their sterile containers and fed yeast and molasses, they produce viable eggs. Tests have shown that the larvae require the same ten amino acids that are essential to the rat and that eight water-soluble vitamins are essential, namely, biotin, pantothenic acid, choline, folic acid, pyridoxine, riboflavin, niacin, and thiamine. The diet does not contain any of the chemicals that give onion its distinctive odour and taste. The balance of the relative amounts of nutrients is very critical and has not yet been fully determined.

ESTABLISHING ASEPTIC CONDITIONS

Some insects can be rendered aseptic simply by immersing their eggs in a disinfectant. The author has found that eggs of *Hylemya antiqua* (Mg.) that are less than 24 hours old can be disinfected by immersion in 6.5 per cent formalin for 30 minutes. Older eggs are more heavily infected and connot be disinfected by this treatment. House (8) immersed the larvae of *Pseudosarcophaga affinis* (Fall.) in 6.5 per cent formalin without ill effects. The method used to obtain aseptic insects depends to a great degree upon the species, and consequently generalized directions are not very helpful. Adding a wetting agent or a weak solution hydroxide to the disinfectant helps to sterilize the chorions of lepidopterous larvae such as the armyworm, *Pseudaletia unipuncta* (Haw.). Antibiotics have been tried for sterilizing the gut of some insects and for controlling microorganisms in their diets, but these attempts have been unsuccessful because of the harmful effects of the chemicals.

Care must be taken when sterilizing the chemical diets. If heat is used as the sterilizing agent it can cause harmul changes in the diet, such as the combination of sugar and amino acid molecules, rendering these molecules nutritionally unavailable. Many vitamins break down if heated too severely under unfavourable pH conditions. These harmful effects can be minimized by keeping reactive groups of chemicals in separate mixtures until just before the final formulation, or by sterilizing some of the dietary elements by filtration and formulating the final mixture at temperatures just above the melting point of agar.

A new method of sterilizing diets by using ethylene oxide or similar gases has been developed recently (1). Meat and other foods have been sterilized by exposure to a source of ionizing radiation (5). The latter treatment causes a minimum of chemical change in the food and therefore would probably be an excellent way of obtaining sterile insect diets.

MEASUREMENT OF DIETETIC EFFECTS

Many criteria may be used to measure the effects of the experimental diets. One of the most suitable is the rate at which the insects develop. One can measure the growth rates by observing change of form, such as the development of first-, second-, and third-instar mouth hooks in some dipterous larvae. Change in size, as measured either directly or by silhouette, is another criterion (9, 14,). Changes in weight have also been used; House and Patton (7) have described an appartus by which cockroaches can be weighed quickly under aseptic conditions.

Whenever possible, the experimental results should be analyzed statistically. Litchfield (10) has developed a method for the rapid graphic analysis of time-per cent effective curves that is most useful.

As more and more nutritional studies are conducted on plant-feeding insects, and certain basic principles are made clear, it should be easier to formulate satisfactory chemically defined diets. A more thorough understanding of the dietary requirements of insects will add greatly to knowledge of the basic physiology of this class of animals.

SUMMARY

Some of the difficulties facing a worker attempting to rear phytophagous insects aseptically on chemically defined diets are described. The problem of making diets that satisfy the insects' micro-ecological requirements of tactile and chemical attractiveness are discussed and also the difficulties in obtaining the correct physical consistency and nutritional balance of the diets. Methods of rendering insects and diets aseptic are outlined. Results of applying these techniques to a study of the nutrition of the onion maggot, *Hylemya antiqua* (Mg.), are given.

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STUDIES ON THE NUTRITION OF THE SOUTHERN ARMYWORM *PRODENIA ERIDANIA* (CRAMER).

K. R. Elliott[1]

ABSTRACT

These studies were carried out at the University of Western Ontario from 1952 to 1954 to determine the basic nutritional requirements of the southern armyworm, *Prodenia eridania* (Cramer), by means of an artificial diet. Because the larvae normally feed on the exposed surfaces of host plants, it was necessary to contain the diet in an agar medium that approximated leaf material in consistency and water content. However, it was found that larvae of the first three instars could not feed from the flat upper surface of the medium. This feeding difficulty with exposed leaf-feeders was also encountered by Wellington (8), but it was here overcome by piling thin strips of the medium in a criss-cross manner so that the larvae had access to spaces and crevices below the upper surface. Of several strip methods tried, the best results were obtained with corrugated strips cut from a solid block of the medium with a vegetable garnisher.

All stages of the southern armyworm were reared at 80°F and 70% R. H. Three replicates of 10 newly-hatched larvae were started on each test medium and on the fresh head-lettuce used for controls. Food was changed daily. The larvae were not treated to prevent the introduction of fungi and bacteria carried on their surfaces but all equipment used in handling the larvae and the media was sterilized before use. In addition, a mold-inhibitor was added to media containing leaf material, and media containing purified substances of known chemical composition (artificial diets) were autoclaved. (The latter method was used without detrimental effect by Beck and Stauffer (2) with diets for the European corn borer.) However, the formation of moisture on the walls of the rearing jars when closed-tops were used promoted fermentation of the media; this was overcome by capping the jars with absorbent tissue that allowed excessive moisture to escape without causing the media to dry out.

In connection with the preliminary feeding experiments that were carried out to overcome the feeding difficulty, various media containing macerated head-lettuce suspended in a bacto-agar jelly with added brewer's yeast powder and sodium proprionate (mold-inhibitor) were tested and optimal amounts determined. On the best of these foliage media, survival was no less than that attained by control larvae reared on fresh head-lettuce, but the larvae required 30 days to reach an average body-weight less than one-third of that of 22-day control larvae and the pupal stage was not reached. Because the rate of growth was increased

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if less heat was used in preparing the medium, it was thought that heat had destroyed an element in the lettuce that was essential for pupation. It is also possible that maceration of the lettuce produced a deleterious effect.

Following the preliminary experiments, a total of 68 artificial diets were prepared and tested. These contained purified nutritive substances suspended in a bacto-agar jelly with fibrous cellulose added as non-nutritive bulk. The basic agar-cellulose carrier was adapted from that used by Bottger (3), and the nutritive materials were selected on the basis of knowledge gained by various investigators as summarized by Trager (7), with special reference to the work of Beck, Lilly, and Stauffer (1), Beck and Stauffer (2), and Crowell (3).

A first group of 28 diets contained nutritive materials in proportion to the carbohydrate, protein, lipoid, and mineral content of cow's milk on the basis of a statement made by Fraenkel (5) that the composition of cow's milk approximates that of green leaves. In this group, the basic diet contained glucose or sucrose, or both sugars in the ratio of 1 to 2, casein, corn oil, Wesson's salts and vitamins were represented by brewer's yeast powder. On this diet, the larvae developed to the 3rd instar only and the average weight was just 0.6% of that attained by control larvae on fresh head-lettuce. With corn oil replaced by cholestrol and linoleic acid, the larvae developed to the 5th instar and the average weight increased to 1.3% of that of control larvae. By using cholesterol and linoleic acid in combination with corn oil, the larvae did not develop beyond the 5th instar but the average weight increased slightly to 1.5%. The further addition of choline chloride allowed development to proceed to the 6th, or final, instar in a few cases, and the average weight increased to 2.5%. When both choline chloride and chlorophyll were added, development was not improved but the average weight increased to 3.1% of that of control larvae. These results were obtained when the diets contained 87% water and parallel but poorer results were obtained with similar diets that contained 80.5% water.

In a second group of 20 diets, the materials were included in the proportions found in head-lettuce as listed by Winton (9). The water content was 87%; carbohydrates were provided as glucose and/or sucrose; protein as casein; lipoids as combinations of cholesterol, linoleic acid and corn oil; minerals as Wesson's salts; and vitamins as brewer's yeast powder with additional choline chloride. Four quantitative combinations of the lipoids and vitamins were tested, and each combination was tested with glucose and sucrose individually or combined in the ratio of 1 to 1, 1 to 2, and 2 to 1. Nearly all of these diets supported development to the final instar, the highest average weight being 7.3% of that of control larvae. Although the results were only a slight improvement over those obtained in the first group, it was shown that carbohydrates could be provided either as glucose or sucrose because the results achieved with either sugar were not consistently less than those obtained with both sugars. Sucrose was inferior because it promoted rapid fermentation. Also, the best results were obtained with diets that contained cholesterol, linoleic acid, and choline chloride in amounts approximating those used by Beck and Stauffer (2) in diets for the European corn borer.

Following the addition of N. B. grass juice powder (Cerophyl Laboratories) to diets of the second group, development and growth were greatly improved. On five of the diets, apparently normal pupae developed but adults failed to emerge. During the first four instars, the average weight of the larvae on the best of the diets was equal to that of the controls and the weight of the heaviest individuals even exceeded that of the heaviest control larvae. However, growth slowed down during the last two instars and the highest average weight lowered to 69% of that of control larvae. As in the second group, it was found that qualitative variation of the sugar content produced no consistently different results.

Although the best diet developed was suitable only for the larvae of *Prodenia eridania,* this is the first instance of an exposed leaf-feeding insect having been reared through all feeding stages on an artificial diet. It was also shown that: (a) carbohydrate requirements could be satisfied by glucose or sucrose even though Crowell (4) determined that these sugars are utilized in the ratio of 1 to 2; (b) lipoid requirements could not be satisfied by corn oil alone

because cholesterol and linoleic acid proved to be essential for larval development; (c) brewer's yeast powder as a source of B vitamins required additional choline chloride; (d) chlorophyll produced a feeding stimulus but did not contribute to the nutritional value of the diet; and (e) an undetermined factor in grass juice powder proved to be essential for pupation. The last material was used successfully by Fraenkel and Blewett (6) in a diet for the Mediterranean flour moth, *Ephestia kühniella* Zeller, who found that it could be replaced by synthetic folic acid. Beck and Stauffer (2) found that a similar material, S. B. J. plant factor preparation (Cerophyl Laboratories), was essential for the European corn borer, *Pyrausta nubilalis* (Hubner).

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THE NUTRITION OF *AEDES AEGYPTI* L.

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ABSTRACT

The nutrition of mosquito larvae has been successively elucidated by Trager, Golberg and De Meillon, and Hilchey. The nutrition of the adult female mosquitoes already the object of many studies made by entomologists on the necessity of the blood meal, has recently been characterized by DeLong and his co-workers, who have been able to substitute milk, casein and finally 18 common amino acids for the blood meal. Since the adult requirements may be considerably modified by the nutrition during the larval stages, our studies at the University of Western Ontario, comprise the nutrition of the mosquito in both stages.

Sterile larvae were first successfully raised on a diet consisting of the water-insoluble residue of yeast together with glucose, inorganic salts, RNA, thiamin, riboflavin, niacin, pyridoxin, pantothenic acid, choline chloride, and folic acid proved to be a good diet. The insoluble yeast residue was then successfully replaced by vitamin-free casein, lecithin, cholesterol, cephalin, BT, B[12], and Glutathione. The work is proceeding on the replacement of vitamin-free casein by the constituent amino acids, and here the major problem is the osmotic pressure of the medium.

In the studies of the nutritional requirements of the adult female mosquito for ovulation, we were able to induce the maturation of ova in the ovaries up to the fifth stage of Christophers by giving the adult female 10 essential amino acids administered together with honey on a cotton pad. Dimond, Lea, Brooks, and DeLong (1955) have obtained ovulation in mosquitoes fed with 18 amino acids.

Studies on the nutrition of adult *Aedes aegypti* have so far shown that they require much the same amino acids as the larvae do. Most species of mosquitoes can mature their first batch of eggs without a blood meal, presumably because they carry over sufficient store of amino acids from larval nutrition. The species we are studying *(Aedes aegypti)* is unusually demanding that it does require a blood meal to mature even the first batch of eggs.

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CONCLUDING REMARKS[1]

H. L. House[2]

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This discussion has produced much information on nutritional requirements and artificial diets for insects. It was necessary to condense the results of a number of significant studies to present the essence of the present knowledge in capsule form. Perhaps some of these capsules were difficult for some to swallow. For example, I suggested the possibility of a universal diet capable of supporting growth of any insect. In doing so, I realized that this may be a premature and rash conclusion at this stage of our knowledge. However, I wished to emphasize that the dietary requirements of all insects studied are found among about 30 nutrients and that no important differences having taxonomic significance have been brought to light. Consequently when one surveys the countless variety of sources of organic food stuff, plant and animal, on which insects feed, the complex food problem can be much simplified in terms of these 30 or so common substances. Possibly nutrients such as carnitine (3, 5) and unidentified substances such as Beck's corn leaf factor (1) may prove to have greater importance and may in time alter the picture. It was also pointed out that various substances impart distinctive odours or flavours to insect foods and that these flavours and odours may be necessary to stimulate the feeding response though they have no essential nutritive role.

The nutritional requirements of insects are closely similar to those of vertebrates. This makes it easier to understand insect nutrition. Nutritional techniques used with vertebrates usually can and should be used in nutritional studies with insects. In fact, almost utopian refinements in techniques can often be used with insects—refinements that are usually not attained with larger animals. Some of these techniques have been described by Wressell, Friend, Elliott, and Singh in their discussions today, for example, feeding experiments with natural foods and with artificial foods that included diets that are highly purified and chemically definable as well as aseptic techniques to avoid the possible intervention of symbiotic microorganisms, which may provide miscellaneous nutrients.

Wressell's problem in rearing the corn borer on a highly purified diet may not find a ready solution in the discussions today. Both he, using Beck's diet, and Elliott, using an artificial diet for the southern armyworm, have had limited success. Both these diets apparently lack an unknown factor—a factor that may not itself complete the dietary requirements of the insect. Even with the grass juice factor the southern armyworm failed to develop beyond the pupal stage. The most obvious manifestations of an unsuitable food are slow development and the premature death of the insect. These effects may be attributed to the complete lack of an essential substance, to exhaustion of nutritive substances, and to the toxic effects of some chemicals; also, the physical structure of the food may make it difficult for young larvae to move and cause them to die of exhaustion. Normal development depends on the availability of all the required substances and upon the ability of the insect to utilize them. Food utilization depends on digestion and on the rate at which food is passed through the digestive tract. Here we become concerned with problems in formulating synthetic diets that may contain indigestible fillers such as methyl cellulose or, at the other extreme, nutrients in solution, such as glucose or inorganic salts, which are readily available and are osmotically active. Singh was aware of this latter point in his discussion on rearing *Aedes aegypti* (L.). Wressell pointed out that with the corn leaf factor in the diet the corn borer grew rapidly and adults were obtained but vigor decreased in the succeeding generations. This indicates the cumulative effect of nutritional deficiencies. The requirements of insects studied have dealt only with one generation; reliable determination of requirements must involve rearing the insect through

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[1]Contribution No. 3415, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada; presented at the 92nd Annual Meeting of the Entomological Society of Ontario, Guelph, October 31-November 2, 1955.

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several generations to detect symptoms of long-term deficiencies. This has not yet been carried out; when it is done, some of the nutrients, such as inositol, that are now considered non-essential, may be found essential.

Some phytophagous insects studied, namely, the onion maggot (6), the rice stem borer (7), and the pink bollworm, *Pectinophora gossypiella* (Saund.) (2), do not seem to require unknown factors for satisfactory growth. Friend, however, includes coenzyme A, thioctic acid, inosine, and thymine in his diet for the onion maggot.

The work of both Elliott and Friend emphasizes the importance of providing suitable micro-environmental conditions to induce the insect to feed. It should be remembered that a biting response may be stimulated by internal physiological factors, such as hunger, or by external factors, such as sensory stimulations. Insects may bite into substances "for reasons which have nothing to do with nutrition, e.g. burrows made in wood, or even lead" (9). Chin (4) pointed out that four factors are involved in selecting food by the Colorado potato beetle, namely, olfaction, gustation, tolerance to toxic substances, and nutrition; suitability of the food depends on the compatible combinations of these factors. These factors relating to food plants should be remembered when attempts are made to rear phytophagous insects on artificial diets.

Much of our discussion relates to phytophagous insects, their nutritional requirements, and the rearing techniques. For contrast Singh presented studies on a different type of insect, *A. aegypti,* which is aquatic in its immature stages. We have noted the similarity, however, between the nutritional requirements of phytophagous species and of the mosquito—similarities that extend even to the entomophagous parasite *Pseudosarcaphaga affinis* (Fall.). Singh dealt to some extent on the requirements for ovulation. Requirements for reproduction may be different from those for growth in insects, as in vertebrates—the differences being quantitative as well as qualitative. High-quality protein, that is, one that consists of all the common amino acids, is important for reproductive processes. Isoleucine and some of the other amino acids are effective in reproduction. There is evidence that some of the vitamins play important roles. Pantothenic acid, rich in honey bee royal jelly, should be investigated. Unfortunately our present knowledge on this subject is very limited.

We have suggested that resistance of plants to insect attack may depend on their nutritive composition. There is evidence to support this, though Painter (8) mentions that there is no clear evidence of such a relationship. However, we should continue to investigate the possibility of such a relationship as present knowledge of the composition of plants and of the requirements of insects is too limited to draw final conclusions.

Obviously nutritional physiology is basic to most entomological problems. Much information has been obtained on the requirements of insects by carefully controlled feeding tests, and considerable skill has been developed in rearing, often aseptically, insects on synthetic diets. Purified synthetic diets and tedious techniques will continue to be highly prized, sharp, though fragile, tools for the specialists to use in experiments to increase our knowledge of insect nutrition. Such methods, however, may not be as useful, or even necessary, for entomologists with other interests. For example, most of our knowledge of human nutrition has been gained from the rat or human subject fed on highly purified or chemically defined synthetic diets similar to the insect diet described by Friend and consisting of pure amino acids, sugar, vitamins. Few persons, if any, prefer such a diet to meat, vegetables, and fruit. However, the information obtained with these chemical diets is applied by the housewife and the dietician in selecting meat, vegetables, cheese, eggs, fruits, etc., in combinations that supply the optimum daily quantities of protein, vitamins, and other dietary essentials. Frequently visitors, after viewing my work with the parasite *P. affinis,* which is reared aseptically and individually on a chemically defined diet at Belleville, ask me with a note of skepticism, "But is this a *practical* method for rearing parasites?" The answer is no; it is no more practical than feeding one's family on the synthetic, chemical diets used in human nutritional research. Entomologists, like the dieticians, should apply the fundamental information from such studies and with this information be better able to select nutritionally

satisfactory food materials for insect diets. In rearing the corn borer aseptically and individually on a highly purified diet, Wressell has met certain experimental prerequisites but he is unable to maintain his stock. Often it is more practical to use artificial foods, e.g., hydrolysed casein or yeast extract, than to attempt to use natural foods in the laboratory. At present we may not be able to find a ready solution to his problem from the information at our disposal. Possibly, however, as his immediate interest is not essentially nutritional, he might have better success in rearing the borer, without sacrificing other experimental prerequisites, if he tried natural foods similar to those used by Wellington (10) and by Elliott in his early work.

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SYMPOSIUM

II

CHANGING FAUNAL RANGES

Chairman: A. W. Baker *Co-ordinator*: H. W. Goble

Panel: W. W. Judd
H. W. Goble
R. W. Sheppard
R. D. Bird
E. M. Walker

INTRODUCTION

This symposium on changing faunal ranges was, I believe, really inspired by the very interesting and informative paper presented by Dr. Walker at the Annual Meeting last fall. In view of this it is particularly gratifying that Dr. Walker has consented to lead the discussion following the panel speakers.

Since I agreed to chair this symposium I have been trying to see something of the picture for myself. That life zones in the northern hemisphere are changing there seems no question. Evidence runs all the way from the appearance of moose north of the Albany River to "die back" of birches. In my hurried reading I find rather a lack of agreement amongst the meteorologists and physicists. The suggestion is made that we really should be entering a colder cycle yet all seem to agree that we have an increasing annual mean temperature. Suggestions as to the factors responsible range from a tilting of the earth's axis as a result of the increasing antarctic ice cap to an increase of CO_2 in the atmosphere as a result of our tremendous use of coal and oil as fuel. We shall now hear the first speaker.

INSECTS OF THE CAROLINIAN ZONE OF ONTARIO

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As my contribution to this symposium I wish to discuss insects that occur particularly in the Carolinian Zone of Ontario—not as a consideration of changes in the faunal range but rather as a consideration of insects indigenous to a faunal area which is concentrated mainly to the south of us and which has a slight northern extension into southern Ontario.

Many authors who have drawn maps to show bio-geographic regions in North America have included a narrow strip of territory, lying along the north shore of Lake Erie between the western end of Lake Ontario and the southern end of Lake Huron, as part of a larger faunal area, the Upper Austral Zone, which extends southward over much of the eastern United States. Furthermore, they have indicated that the Upper Austral Zone penetrates into Canada at no other point, thus making this part of southern Ontario unique in Canada. Merriam (12) showed the Upper Sonoran Region extending across the continent from Atlantic to Pacific and described the more humid division of the Region, east of the Great Plains, as the Carolinian Faunal Area, "Carolinian" being a term used by earlier authors, e.g. Cooper (2). In a later paper (13) Merriam used the term Upper Austral to describe what he formerly included as the eastern part of the Upper Sonoran and he defined the Carolinian Area in terms of its fauna and flora by pointing out that it is an area in which, counting from the north, "sassafras, tulip tree, hackberry, sycamore, sweet gum, rose magnolia, redbud, persimmon, and short-leaf pine first make their appearance . . . . together with the opossum, gray fox, fox squirrel, cardinal, Carolina wren, tufted tit, gnatcatcher, summer tanager, and yellow-breasted chat". One might also add to this list, among the Amphibia, Fowler's toad, *Bufo fowleri* Garman, which is found along the beaches of Lake Erie (17).

Attemps to fix the boundary of the Carolinian Zone in Ontario have been based mainly on studies of the flora. Macoun and Malte (10) defined the Carolinian Zone by stating that it was "confined to a small tract of land in southern Ontario, bounded to the south by Lake Erie and to the north by a line running approximately from the northern shore of Lake Ontario to Windsor". They listed several trees and herbaceous plants which they considered characteristic of this Zone. Halliday (6) described a "Deciduous Forest Region" having a northern boundary coinciding with that of the Carolinian Zone as described by other authors and including such trees as chestnut, tulip tree, blue ash, magnolia, pawpaw, Kentucky coffee tree, etc., which have their northern limits in this deciduous forest. Fox and Soper (3, 4, 5) studied and plotted the distribution of 41 trees and shrubs in southern Ontario and used the resultant data to determine if it was possible to draw a northern boundary for the Carolinian Zone in Ontario. They chose 26 species restricted to the Carolinian Zone (5) and, for each species, they drew lines connecting the northerly marginal stations to outline the limits to which that species was known to extend. A smoothed curve was then drawn through the resultant northerly limits of the 26 species and taken to represent a boundary for the Carolinian Zone. This boundary "starts at about Grand Bend on Lake Huron, dips south-eastward nearly through London, curves south of Oxford County, then northeastward around

Galt and then east to include a strip along the north shore of Lake Ontario through Halton and Peel counties and the western part of York County to a spot just east of Toronto". This boundary shows a good correlation with isopleths, presented by Putnam and Chapman (15), for the length of the frost-free period or length of the growing season. So the location of the boundary is probably related to climatic conditions rather than to edaphic factors.

Plants are more clearly zonal in their distribution than most animals and attempts to define faunal areas by their animal inhabitants are complicated by the evident ability of animals to wander from their native range. Life zones do, however, have characteristic animals associated with them and one of the major contributions to the study of life zones in North America, that of Merriam (12), was based largely upon the study of the distribution of mammals. Two recent monographs on insects of North America, Klotz (9) and Muesebeck et al. (14), include maps showing life zones in North America. Both these maps indicate the Carolinian Zone of southern Ontario as an extension northward of the Upper Austral. Klotz (9) presents a list of 17 species of butterflies characteristic of the Austral Zones.

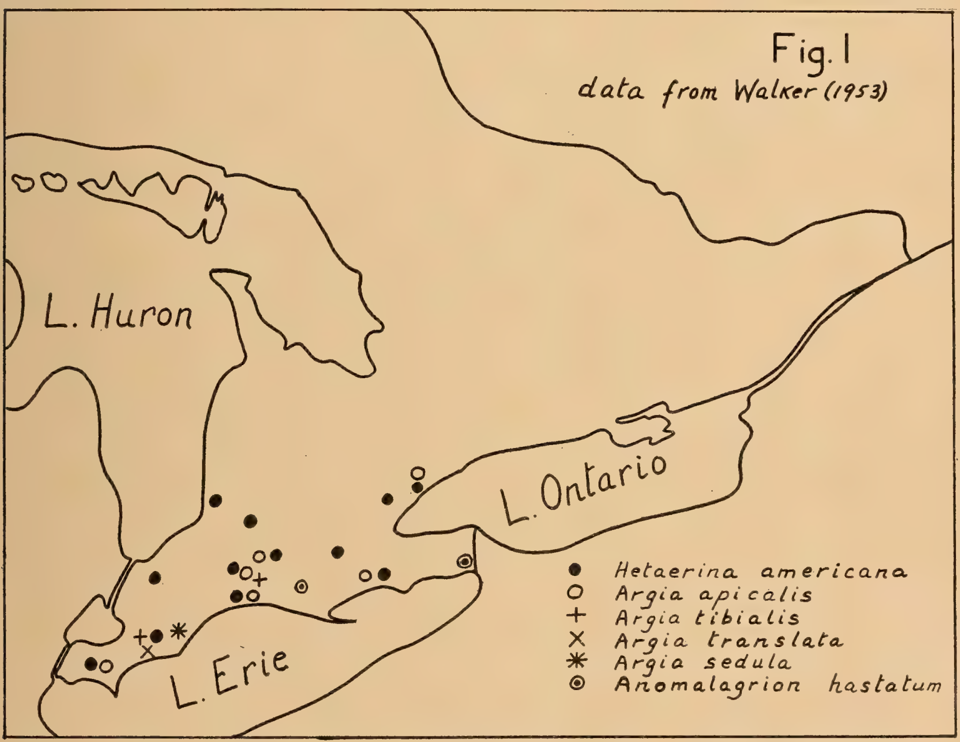

Fig. 1—Distribution of Carolinian Zygoptera in Southern Ontario.

ODONATA

One order of insects in which several species are known to be restricted, in Ontario, to the Carolinian Zone is the Odonata. Walker (18) reports that in general the Carolinian fauna in Ontario is rich in Zygoptera and Libellulidae and comparatively poor in Corduliidae and Aeschnidae. His list of species restricted in Ontario to the Carolinian Zone or rarely found beyond its limits is as follows: Zygoptera—*Hetaerina americana* (Fabr.), *Argia apicalis* (Say), *A. tibialis* (Rambur), *A. translata* Hagen, *A. sedula* (Hagen), *Anomalagrion hastatum* (Say); Anisoptera—*Perithemis tenera* (Say), *Libellula semifasciata* Burm., *Pachydiplax longipennis*

(Burm.), *Celithemis eponina* (Drury), *Trapezostigma carolina* (L.), *T. lacerata* Hagen and *Pantala hymenea* (Say). The distribution of these 13 insects is shown plotted in Fig. 1 and 2, using distributional data in Judd (7) and Walker (18, 19). Walker (18) points out that owing to the flatness of the Carolinian Zone in Ontario pond species are abundant and the paucity of stream species has been intensified by a drying up of watercourses and the irregular flow of those which remain, due to overclearing of the land.

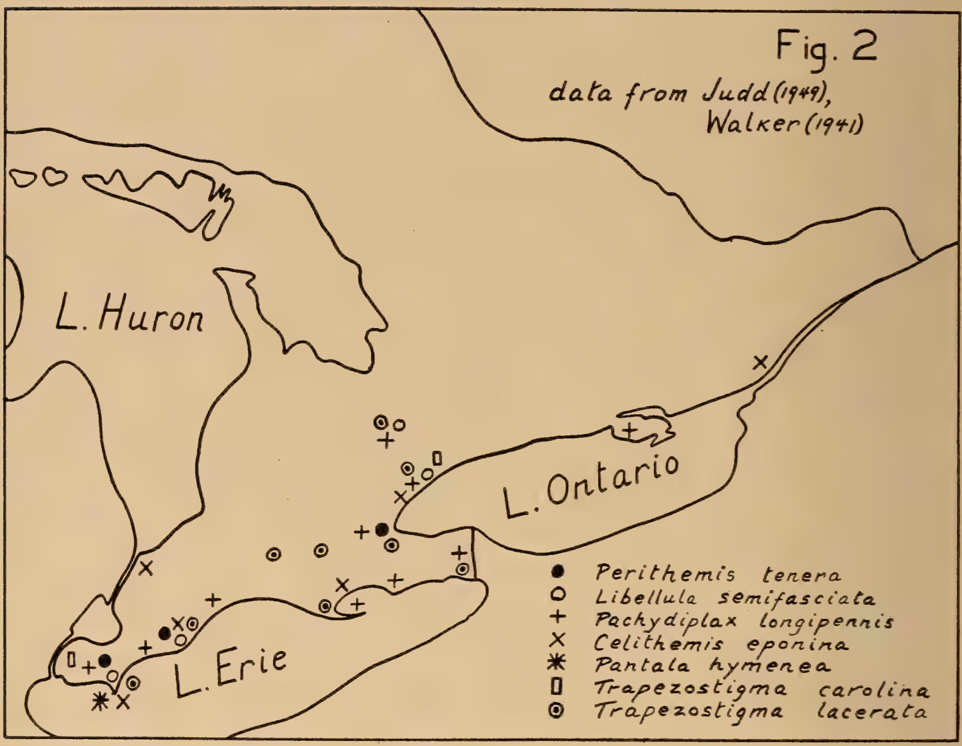

Fig. 2—Distribution of Carolinian Anisoptera in Southern Ontario.

LEPIDOPTERA

Among the Lepidoptera there are several butterflies whose food plants are restricted in Ontario to the Carolinian Zone or adjacent parts of Ontario. The zebra swallowtail, *Papilio marcellus* Cramer, has as its host plant the pawpaw, *Asimina triloba* (L.), Dunal, which Fox and Soper (3) show distributed only in Welland, Lincoln, Oxford, Elgin, Essex, Kent, and Lambton Counties. The giant swallowtail, *P. cresphontes* Cramer, is described by Klotz (9) as an insect of the Austral Zone. Its food plants are the hop tree, *Ptelea trifoliata* L., and the prickly ash, *Xanthoxylum americanum Mill.* The former is known only from Essex, Kent, and Welland Counties (3) while the latter extends northward and eastward as far as Renfrew County (3). The caterpillar of the spicebush swallowtail, *P. troilus* L., feeds on prickly prickly ash, sassafras, *Sassafras albidum* (Nutt.) Nees, and spice bush, *Lindera Benzoin* (L.) Blume. Sassafras is restricted to the Carolinian Zone (3, 5) while the spice bush extends northward beyond the Carolinian into Grey County and eastward along the north shore of Lake Ontario (3). Another swallowtail that is of southern distribution and is found in southern Ontario (9) is the pipe vine swallowtail, *P. philenor* L., whose larva feeds on Dutchman's pipe, *Aristolochia,* and occurs about cities where this vine is grown.

Another tree found in Ontario mainly in the Carolinian Zone, but with extensions of range northward and eastward (1), is the hackberry, *Celtis occidentalis* L. It is the food plant of three butterflies found in southern Ontario, the tawny emperor, *Asterocampa clyton* Boisduval and Leconte, the hackberry butterfly *A. celtis* Boisduval and Leconte, and the snout butterfly, *Libytheana bachmanii* Kirtland.

Some butterflies which were formerly found only rarely in extereme southern Ontario before 1900 have become more common or have extended their range farther northward in recent years. Among these are the variegated fritillary, *Euptoieta claudia* Cramer, and the buckeye, found only rarely in southwestern Ontario in the early part of the century, has including violets and mayapple and can be expected to increase its range northward. The buckeye, found only rarely in southwestern Ontario in the early parts of the century, has since then increased in abundance and extended its range northward at least as far as Lake Simcoe. Klotz (9) records that in the northernmost parts of its range it may not survive the winter, the population being annually renewed by northward migration. Its further extension northward may depend upon the development of a cold-hardy population or upon a gradual warming of the territory to the north of its present range.

In the family Pieridae there are a few species that are found only in extreme southern Ontario (9, 11). The commonest of these is the little sulphur, *Eurema lisa* Boisduval and Leconte. Occurring more rarely are the dog face, *Colias cesonia* Stoll, the Mexican sulphur, *Eurema mexicana* Boisduval, and the sleepy orange, *Eurema nicippe* Cramer.

EPHEMEROPTERA

Dr. F. P. Ide, University of Toronto, contributing *(in lit.)* information on the distribution of mayflies for this symposium, commented that "the fauna has a southern aspect in general at the lower end of rivers of moderate size, e.g. Credit, Thames, Grand and Ausable in southern Ontario." In the Credit River, at Erindale, he found a mayfly, *Stenonema interpunctatum interpunctatum* Say, which is generally distributed further south and is replaced in most sections of Ontario by another subspecies, *S. i. canadense* Walker. He pointed out that a stream, because of its very great differences in environmental conditions from source to mouth tends to cut across all geographical lines and that mayflies have much less power of dispersal than some other groups such as Odonata, among aquatics, and butterflies and moths among terrestrials.

ORTHOPTERA

Urquhart (16) studied the Blattaria and Orthoptera of Essex County, the most southerly county in the Carolinian Zone of Ontario, and reported that "Essex County can rightly be regarded as within the Carolinian area of the Austral Life Zone". On Point Pelee the presence of the mole cricket, *Gryllotalpa hexadactyla* Perty, gave striking evidence of the austral aspect of the fauna. Three other typically southern insects were the short-horned grasshoppers *Pseudopomala brachyptera* (Scudder), *Metaleptea brevicornis* (L.), and *Paroxya hoosieri* Blatchley.

HYMENOPTERA

Among the Hymenoptera, *Hyptia harpyoides* Bradley (Evaniidae), is included as an insect of the Austral Zone by Muesebeck *et al.* (14) Two specimens of this species, identified by Dr. O. Peck, Systematic Entomology, Department of Agriculture, Ottawa, emerged on May 9, 1955 from two egg cases of the roach, *Parcoblatta pennsylvanica* (DeGeer), collected by the writer on September 11, 1954, in Rondeau Park, Kent County. Another wasp, *Systellogaster ovivora* Gahan (Pteromalidae), has recently been recorded, for the first time in Canada, from Rondeau Park (8). One of the fire ants, *Dasymutilla vesta* (Curran) (Mutillidae), has been taken on Point Pelee by G. Beall, August 17, 1934.

ARANEIDA

Dr. W. J. Gertsch, American Museum of Natural History, New York, has contributed (*in lit.*), for this symposium, the following list of spiders which are known from the Carolinian Zone in the United States and have been collected in southern Ontario:: Atypidae (purse-web spiders)—*Atypus niger* Hentz; Uloboridae-*Hyptiotes cavatus* Hentz (triangle spider); Dictynidae (hackled band weavers)—*Dictyna volucripes* Keyserling, *D. formidolosa* Gertsch and Ivie; Gnaphosidae (running spiders)—*Gnaphosa sericata* Koch, *Sergiolus variegatus* Hentz, *S. decoratus* Kaston; Clubionidae (sac-spiders)—*Clubiona pallens* Hentz, *C. obesa* Hentz, *Trachelas ruber* Keyserling, *Meriola decepta* Banks; Theridiidae (comb-footed spiders)—*Conopistha trigona* Hentz; Argiopidae (orb-weavers)—*Theridiosoma radiosa* McCook, *Tetragnatha caudata* Emerton, *Micrathena sagittata* Walckenaer, *Metepeira labyrinthea* Hentz; Mimetidae (mimetids)—*Mimetus notius* Chamberlin.

The foregoing account indicates that there are several species of insects that are confined, in Ontario, to the Carolinian Zone. This is particularly noticeable in groups, such as the Odonata, in which the distribution of the species in Ontario has been studied in detail. Doubtless there are many other insects, which, on the basis of their present known distribution, can be shown to be restricted to the Carolinian Zone; and many also that once were known only from the Carolinian and that have since extended their range northward. Further intensive collecting in southern Ontario will serve to show more exactly the northern limits of distribution of Carolinian insects and will no doubt bring to light other species which will be found to be restricted to this Carolinian Zone.

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EXTENSION OF THE RANGE OF SOME INSECTS OF CENTRAL ONTARIO

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Records received at the Ontario Agricultural College over a period of years concerning distribution and density of population of a few economic insects in central Ontario may help show the changes in this area. Systematic surveys concerning the insects to be discussed have not been made. However, these insects and others, which occurred occasionally at an earlier time only to be reduced or eliminated by some environmental factor later, have become important in the production of agricultural crops. The following insects will be discussed: Mexican bean beetle, European mantis, European earwig, and San Jose scale.

MEXICAN BEAN BEETLE, *Epilachna varivestis* Muls.

McLain (6) reported the first occurrence of this pest at Cedar Springs, Kent county, in 1927. Caesar *et al* (2) in 1930 wrote: "Only two small infestations, one at Walsingham in Norfolk and the other at Fonthill in Welland county, were found. The insect seems to be making no headway in the province." References were made occasionally to this pest in the Annual Reports of the Entomological Society of Ontario from 1931 to 1937. All showed that the Mexican bean beetle was present in small numbers.

Records in the annual Reports of the Society from 1938 to 1950 included numerous references to infestations in home gardens and to collections obtained from Japanese beetle traps. There was no reference to injury on a field basis.

From 1952 to 1955 establishment had taken place near Thedford in Lambton county to the extent that large acreages of beans required dusts or sprays. Few official records are available from this area before 1952 but bean growers claim Mexican bean beetles were destructive in 1951 and 1952. Therefore, this pest has been economically important on a field scale since 1950 and not before, even though it probably was introduced to Lambton county about 1927.

EUROPEAN MANTIS, *Mantis religiosus* L.

The first record of this praying mantis in Ontario was in 1914 when Gibson (3) found specimens at Carrying Place, Prince Edward county. In a 1941 report on the biology of the praying mantis, it was recorded as well established from Ottawa and Spencerville in the east to as far west as Fort Erie. Judd (5) found this mantid well distributed in the Hamilton area by 1950.

The first specimen collected at Guelph was by A. W. Baker of the Ontario Agricultural College in 1938. Records at the College from 1938 to 1950 show that this insect had established itself in Wellington and surrounding counties during this time. The more northern records since 1948 are: Blackwater in Ontario county 1948; Bobcaygeon in Peterborough county 1949; Udney in Ontario county 1954; Millington in Ontario county 1955; and Phelpston in Simcoe county 1955. The last three places are in an equivalent latitude to the northern end of Lake Simcoe. Thus the records show that the European mantis is present in the southern area of Ontario at least up to Georgian Bay and the northern end of Lake Simcoe.

EUROPEAN EARWIG, *Forficula auricularia* L.

Twinn (7) reported the first occurrence of the European earwig in Ontario at Ayton, Grey county, in 1938. This pest has spread out slowly in this district to include a general area in the southern parts of Grey and Bruce counties. The earwig appears to be adapted to the climatic conditions here.

Since 1938 several other areas of infestation have been recorded such as Toronto, Galt, Fergus, Elora, Elmira, Arthur, and Kingston. A single specimen was reported in a home in Ottawa in 1951 although this may not be an established infestation.

SAN JOSE SCALE, *Aspidiotus perniciosus* Comst.

The population of San Jose scale in Ontario is small at the present time. However, its range of survival is farther north than formerly. Caesar (1) in 1930 reported the scale as developing normally in an area south of a line from Sarnia to Toronto and in this area to be more severe in the counties borderingLakes St. Clair and Erie and on the south shore of Lake Ontario.

If San Jose scale becomes a problem, as it was a number of years ago, one would expect that the range of normal survival would be farther north as indicated by the records taken in the regular course of nursery inspection in Ontario. Inspection records show that since at least 1949 this scale has remained nearly constant after establishment in areas north of the Toronto-Sarnia line and north of the northern shore of Lake Ontario as reported by Caesar (1). The infestations have been light as they are in the Niagara Peninsula and along Lake Erie. The areas where the scale has persisted include from Millgrove and Hornby in Halton county as far north as Maple and Richmond Hill in York county to Oshawa. Infestations were found at Campbellford, about 20 miles north of Lake Ontario in 1950 with the infestation still present four years later. An established infestation was found near Owen Sound, Grey county, in 1954.

Thus it would appear than San Jose scale establishment has taken place about twenty to thirty miles north of the area of infestation reported in 1930. It is likely that the area immediately south of Georgian Bay is also in the susceptible area.

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NEW ENTRIES OF INSECTS TO THE NIAGARA PENINSULA

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There can be little doubt that many marked, and even profound changes of faunal ranges due to influx from other areas and recessions or disappearances within the area, have taken place in the Niagara Peninsula district within the past two or more decades, but, due to our lack of knowledge of the Peninsula's basic faunal status, I can do no more than give an account of such infiltrating species as have come to my notice within that period.

Some of these changes have been quite pronounced in character, while others can only be termed as tendencies at the present time. Still others would appear to be adventitious occurrences or possibly something in the nature of pioneer or advance-guard attempts at colonization.

The influx into the Niagara Peninsula of insect species, and attempts at colonization, successful or otherwise, form a complicated picture with much accidentally assisted movement, or transportation by man-made vehicles, and factors involving average mean temperature increases, as well as environmental or ecological changes, having to be taken into consideration.

It would appear to be fairly evident, in the light of present knowledge, that the majority of our invertebrates, at least those of economic importance, have reached the Niagara District from the east, south-east, or south, rather than from the west, south-west, or south as would appear to be the case with many a recent influx of vertebrate forms of animal life.

Among insect species invading the Niagara Peninsula District within the past decade or two, the following may be given as examples:—

A small, green leaf-weevil, *Polydrusus impressifrons* Gyll., of European origin, and accidentally introduced into New York State early in the present century, has become firmly established, and increasingly common at the eastern end of the Niagara Peninsula during the past two or more decades.

The imported willow leaf-beetle, *Plagiodera versicolora* (Laich.), another European insect apparently present in eastern New York, and some other eastern states, since the first ten or twenty years of the present century, reached the Canadian Niagara border in the year 1942, and has since become firmly established, and is already occurring in some years in outbreak numbers at the eastern end of the Peninsula.

Comstock's mealybug, *Pseudococcus comstocki* (Kuw.), another invader via the U.S.A., was discovered in Canadian territory on some large catalpa trees in Queen Victoria Park at Niagara Falls in September of the year 1944. By the late summer of the year 1945, it was found to be

distributed intermittently on several species of catalpa trees throughout the city parks and suburban areas of Niagara Falls. This infestation persisted for several years during which time it spread to yew trees and hedges, as well as Dutchman's pipe vines, but in the end was seemingly brought under complete biological control through the good offices of the Belleville Parasite Laboratory, but not before it had appeared and attempted establishment at both ends of the Peninsula.

Note: Of late years there has been a tendency for greenhouse mealybug species such as the citrus and long-tailed to become increasingly common on outdoor flower beds.

The Mexican bean beetle, *Epilachna varivestis* Muls., insofar as the Niagara Peninsula is concerned was first discovered at Fonthill in the year 1930, and since those days with many fluctuations in population, and winter survival, it has gradually got to a point where it is definitely established throughout the Peninsula as an integral part of the resident fauna.

The European pine shoot moth, *Rhyacionia buoliana* (Schiff.), possibly, but not necessarily, reaching the Peninsula direct from Europe, was first found in the Niagara District in the year 1925. Since that time, notwithstanding early and persistent attempts to eradicate the infestations, colonies managed to establish themselves with surprising speed, and within a few years, it was evident that another insect had joined Niagara's permanent fauna.

The Oriental fruit moth, *Grapholitha molesta* (Busck), definitely reaching our border via U.S.A., also joined Niagara's faunal group about 1925, and, as is well known, has managed to maintain itself, through varying fortunes, as an integral part of the fauna ever since.

The Japanese beetle, *Popillia japonica* Newm., gained a foothold at the eastern end of the Peninsula in the year 1940, and has managed to maintain a precarious position on the Niagara River border from that time on. Recently, it would appear to have shifted its attack to the extreme western end of the territory where it seems to be making a determined effort to become established in the city of Hamilton.

The elm leaf beetle, *Galerucella xanthomelaena* (Schr.), first discovery in Canada being in the city of St. Catharines in 1945, has been present in the eastern half of the Peninsula, in one locality or another, in almost outbreak form ever since. This constitutes another invasion of a European insect via the U.S.A., reaching the Niagara district, apparently by artificial means, direct from Massachusetts, or the eastern part of New York State.

The elm casebearer, *Coleophora limosipennella* (Dup.), suddenly appeared in outbreak form along the escarpment between Niagara Falls and St. Catharines in 1941, and has been present, and exceedingly common throughout a large part of the Peninsula, ever since.

The European praying mantis, *Mantis religiosa* L., first came to notice, in really appreciable numbers, at Niagara Falls in the year 1940, and is now a well-distributed and fairly-common insect throughout the district. It was first found at Niagara Falls about 1928.

Among insects which have reached the Niagara Peninsula, persisted for a varying period of time, in some instances several years, and then disappeared or become so reduced in numbers that they practically reached the vanishing point, mention may be made of the pine bud moth or little pine shoot moth, *Exoteleia dodecella* L., found for the first time on the North American Continent at Fonthill in 1928; the privet thrip, *Dendrothrips ornatus* Jabl., prevalent from 1937 to the early 1940's; the Argus tortoise beetle, *Chalymorpha cassidea* Fab., heavy infestations occurring at Fort Erie about 1942; apple and thorn skeletonizer, *Anthophila pariana* Clerck, serious outbreaks occurring in apple orchards in 1931, but few if any records since; the gladiolus thrip, *Taeniothrips simplex* Mor., very prevalent in the year 1930 and for a number of subsequent years, but seldom coming to attention during late years; a dogwood infesting sawfly, *Macremphytus varians* Nort., causing severe defoliating damage for a few years around 1943; the giant hickory aphid, *Longistigma carae* Harr., heavily infesting linden trees on the banks of the Niagara River near the Falls in 1948, and with no other local records before or since.

The Australian cockroach, *Periplaneta australasiae* (F.), another probable invader from the south, was found some years ago infesting a greenhouse in St. Catharines, and has since been occasionally found in school children's insect collections at Niagara Falls.

A large grey juniper aphid, *Panimerus juniperi* DeGeer., appeared in outbreak form in the summer of 1950 among wild growth of Virginia junipers along the north shore of Lake Erie in Welland County; the tremendously heavy infestation by these large greyish coloured aphids was rapidly controlled by swarms of the nine-spotted lady bird bettle which appeared for the feast in great numbers. No further outbreaks of this particular aphid have been reported in the Peninsula since, although it, or a closely related species, is occasionally taken on European nursery stock.

Another insect which appeared and disappeared just as mysteriously, but not in so spectacular a manner, concerned a root infesting form of mealybug belonging to the genus *Coccidella,* which was found in the soil of potted Saintpaulia plants in a greenhouse close to the river bank at Niagara Falls. This discovery constituted the first appearance on the North American Continent of a mealybug genus previously known only from tropical countries. Repeated search for further specimens over a period of several years failed to reveal any further occurrence thereby constituting an appearance and a complete disappearance within the one season.

Other field-collected insects which have appeared and disappeared within recent years include an European tortrix, *Cacoecia oporana* (L.), which suddenly appeared on horse chestnut trees in a nursery at Fonthill in 1950, and just as suddenly disappeared before another season.

In the year 1947, a Chrysomelid beetle, *Pyrrhalta viburni* (Payk.), was collected in the larval form at Fonthill from Viburnum shrubs and subsequently reared to maturity. This insect has not been found in the field since that year.

Of late years, terrifically heavy tree-killing infestations have occurred, in the Niagara border area, on road-side and woodland oak trees, of combined oak knot gall, *Callirhytis punctata* Bass., and horned knot gall, *Callirhtis cornigera* (O.S.), both species of Cynipid gall-wasps. While a Chrysomelid beetle known as the locust leaf miner, *Chalepus dorsalis* Thumb, has also appeared in outbreak form, over a period of years, along the Niagara River bank.

Within quite recent years, since 1950, the smaller European elm bark beetle, *Scolytus multistriatus* (Marsh.), the Vetch bruchid, *Bruchus brachialis* Fahr.), the genista caterpillar, *Tholeria reversalis* (Guen.), the hollyhock weevil, *Apion longirostre* Oliver, and the white peach scale, *Pseudaulacaspis pentagona* (Targ.), sometimes known as the West Indian peach scale, have arrived in the Peninsula area, apparently by natural spread from the south or south-west.

Finally, as a direct threat of invasion in the near future, we have pockets of infestation or occurrences of the European chafer, *Aphimallon majalis* Razoum., at Niagara Falls and Buffalo just across the international border in New York State.

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EXTENSIONS OF FAUNAL RANGES IN THE PRAIRIE PROVINCES[1]

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In primitive times the distribution of the fauna of the Prairie Provinces, as in other areas, undoubtedly shifted considerably with the competition of other species and climatic and

[1]Contribution No. 3404, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada; presented at the annual meeting of the Entomological Society of Ontario, Guelph, November 1-2, 1955.

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habitat changes. Since the coming of the white man, habitats have been changed to a great extent by land clearing and the introduction of intensified agriculture. Conditions are not static and changes are continuing. Species adaptable to new conditions have extended their ranges. Some species have been introduced to the area, and others have disappeared. All forms of life are affected and are so interrelated ecologically that one group cannot be studied without considering others. Mammals and birds are conspicuous and well known. They may often be taken as indicators of changes that also affect insects and other less well known groups.

SPECIES SPREADING WITH AGRICULTURE

Major changes in faunal ranges and abundance have arisen from human activity. The main influx of settlers into Manitoba occurred in the 1880's. At that time the buffalo, *Bison bison bison* (L.), had disappeared and other big game and fur bearers were greatly reduced in numbers. The only deer was the mule deer, *Odocoilus hemionus hemionus* (Rafinesque). It continued to decrease and is now found in only a few scattered herds. Its place was taken by the white-tailed deer, *Odocoilus virginianus dacotensis* Goldman & Kellogg, which invaded the territory, in the early part of this century, from the south and east (16). It was well adapted to life under farming conditions in the aspen parkland, where grain fields alternate with woodland. It has extended its range with settlement and is now found 500 miles to the north where settlers have made clearings in the bush.

The white-tailed jack rabbit, *Lepus townsendii campanius* Hollister, entered Manitoba in the 1880's from the prairie of the Dakotas (17). Grain fields provided an ideal habitat. It is now found 300 miles north of the International Boundary.

The rapid extension of the range of the Colorado potato beetle, *Leptinotarsa decemlineata* (Say), with the introduction of the potato is well known. It appears to have reached the limits of its possible range in Manitoba at The Pas. Here it has been recorded a number of times and may survive for a few years, then die out for a considerable period. It has not been recorded there for the last ten years.

The wheat stem sawfly, *Cephus cinctus* Nort., a native insect, spent its larval stage in the stems of *Agropyron smithii* Rydb., and other large-stemmed native grasses. The planting of wheat gave it a new and more favourable host. It was also aided in its spread to grain fields through the establishment of couch grass, *Agropyron repens* (L.) Beauv., as a common weed. Norman Criddle (6) has recorded how drought caused native grasses to produce stems too small for sawfly larvae and forced the insect to adopt introduced hosts. This has enabled it to extend its range to the west into the wheat growing area of the short grass plains, where formerly the lack of suitable hosts prevented its establishment. More intensive farming, more specialized crop rotations, changes in varieties of wheat grown, and sowing of brome grass on road allowances have now reduced the insect from its former abundance in 1915-1925 in Manitoba, except for a brief increase in the 1930's when strip farming was used to control soil drifting. Strip farming caused the increase by the placing of strips of infested stubble adjacent to strips of growing crops. In Saskatchewan and Alberta the growing of resistant crops, and native parasites, are reducing the area of severe infestation (7).

SPECIES WHOSE RANGES FLUCTUATE WITH CLIMATIC CYCLES

Certain species retract or expand their ranges with fluctuations in climate from wet to dry periods. At the time of the great drought of the 1930's a number of dryland species became very abundant and extended their ranges. Grasshoppers, in particular, spread over wide areas. *Aulocara elliotti* (Thos.) and *Metator pardalinus* (Sauss.) became common in southern Manitoba and Saskatchewan but were restricted to localized areas of most favourable habitat with the return of wetter years. Conversely, during the recent wet years such grasshoppers as *Chortophaga* spp., *Melanoplus bivittatus* (Say), and *Melanoplus dawsoni* (Scudd.) became more common in open grassland (3).

SPECIES WITH ANNUAL NORTHERLY MIGRATIONS

The times and frequencies of southerly winds are a very important factor in insect distribution in the Prairie Provinces. A number of species of insects do not winter in the Prairie Provinces, or do so only in very small numbers, but move in from their wintering grounds in the southern United States. The extent of their northern invasion depends on the timing of southerly winds and the maturity and distribution of their host plants. The greenbug, *Toxopera graminum* (Rond.), the English grain aphid, *Macrosiphum granarium* (Kby.), and the corn leaf aphid, *Rhopalosiphum maidis* (Fitch), pass the winter months on fall-planted wheat and volunteer grains in Oklahoma and Texas and migrate northward with the advance of the season. As they must pass through several generations in so doing, and as they must find grain in the right stage of development at each stop, as well as southerly winds at the correct time, they only rarely reach Western Canada in sufficient abundance to cause an outbreak. A severe outbreak of the greenbug occurred in 1949 and the first outbreak on record of the corn leaf aphid occurred in 1955.

The hessian fly, *Phytophaga destructor* (Say), only occasionally reaches Manitoba and then only in small numbers.

The corn earworm, *Heliothis zea* (Boddie), formerly referred to as *H. armigera* (Hbn.), is a strong flier and occurs regularly but only occasionally in large numbers.

The painted-lady, *Vanessa cardui* (L.), emigrates to wintering grounds in the south and immigrants return in the spring. It fluctuates greatly both in abundance and in extent of its summer range. Only once in the last 25 years, in 1949, has it occurred in outbreak numbers in Manitoba. In that year very large numbers of adults moved in from the south and the resulting larvae caused commercial damage to sunflowers.

Heavy migrations from the south and dispersal of insect species already present in the Prairie Provinces may greatly augment local populations. During grasshopper outbreaks economic infestations of the lesser migratory grasshopper, *Melanoplus mexicanus mexicanus* (Sauss.), in Canada are increased by flights from the United States. The imported cabbageworm, *Pieris rapae* (L.), winters over in very small numbers in Manitoba. Its population is annually increased by flights from the south; sometimes these are spectacular. Stephen and Bird (18) have shown that the butterflies fly during periods of atmospheric high pressure and settle down for egg laying during periods of low pressure.

GENERAL NORTHERLY SHIFT OF POPULATIONS

There are many reports in the literature of a warming of the climate in the northern hemisphere and a gradual northern shift of distributional ranges. Such changes are noted in the Prairie Provinces, particularly among the birds.

Only four records of the American egret, *Casmerodius albus egretta* (Gmelin), in Manitoba were made before 1955, when I found a nesting pair and saw another individual. The first record of nesting American egrets in Saskatchewan was also made in 1955 (8). The first sight records of the bird in Alberta were made in 1954 (13). I observed a red-bellied woodpecker, *Centurus carolinus* (L.), at a feeding station near Brandon, Man., in January 1956. Only a few previous records of this southern bird have been made in Manitoba. The turkey vulture, *Cathartes aura* Wied., is becoming more abundant in Manitoba, and I saw four individuals, apparently two nesting pairs, in July in the Duck Mountains. I also saw a group of seven near Glenboro, where they presumably nested in 1955.

SPECIES INTRODUCED FROM ABROAD

In addition to native species that have extended their ranges, species have been introduced into North America and are gradually extending their ranges until they occupy all suitable habitats.

The sweetclover weevil, *Sitona cylindricollis* Fahr., was first recorded at Hemmingford, Quebec, in 1924 (4). In 1935 it was in outbreak numbers at Newmarket, Ontario, (5) and in 1939 at Brandon, Manitoba. By 1940 it had defoliated sweet clover at Waldeck, Saskatchewan, and by 1943 it was abundant at Medicine Hat, Alberta. By 1947 it was fairly well distributed in the Province of Alberta (2). Just how it reached the Prairie Provinces from Ontario is not known.

The alfalfa weevil, *Hypera postica* (Gyll.), spread out from a nucleus of infestation in Utah in 1904 into Idaho and Montana (10). It was first collected in small numbers in extreme southern Alberta and southwestern Saskatchewan in 1954. In 1955 it had not crossed the Oldman River in Alberta but had spread east 50 miles in Saskatchewan (7).

The European corn borer, *Pyrausta nubilalis* (Hbn.), first appeared in Manitoba and Saskatchewan in 1949. It soon occupied the corn growing area of southern Manitoba and has annually been extending its range in Saskatchewan. In 1955, a year of high population, the range was extended 30 miles northward and 50 miles westward to 50 miles west of the Third Meridian and 50 miles north of the Qu'Appelle Valley (12).

Fruit insects of European origin, long established in Manitoba, are the imported currantworm, *Nematus ribesii* (Scop.), and the currant aphid, *Capitophorus ribis* (L.). The apple seed chalcid, *Torymus druparum* Boh., is a later introduction. In recent years the oystershell scale, *Lepisosaphes ulmi* (L.), has appeared in Manitoba, though it can not withstand the winter temperatures (15).

A number of introduced forest insects have not yet reached Manitoba but are gradually spreading closer to this area. The larch casebearer, *Coleophora laricella* (Hbn.), the European spruce sawfly, *Diprion hercyniae* (Htg.), and the European pine shoot moth, *Rhyacionia buoliana* (Schiff.), are now found in Minnesota (14).

During the past two or three years the Norway rat, *Rattus norvegicus* (Erxleben), has become established in Alberta (7). It has gradually spread westward from much earlier infestations in Manitoba and was preceded in its migrations by the house mouse, which occurred in Manitoba as early as 1882 (16).

The English sparrow, *Passer domesticus domesticus* (L.), spread rapidly west from centres of introduction in the eastern United States. It reached southern Manitoba in 1892, was common in 1894, and extended its range to Athabaska Landing, Alberta, by 1904 (16).

The starling, *Sturnus vulgaris vulgaris* L., has also spread northward, westward, and southward from areas of introduction in the northeastern United States. It was first recorded from the Northwest Territories, 26 miles west of Fort Smith, in 1954, the previous northernmost record being Churchill, Manitoba, in 1953 (9). It was also reported as resident at Lethbridge, Alberta, in 1954 (7). It has been nesting in southern Manitoba for a number of years but the population is not large and only occasional flocks are seen.

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SUMMARY OF SYMPOSIUM

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Such a great variety of material has been presented by the various speakers this afternoon that I find myself quite unable to recapitulate or summarize it. It seems to me, however, that this material involves several quite distinct problems. In a sense all species of animals and plants that enter this country from somewhere else, and become established here, make a change in the life zone they enter. Thus the introduction of foreign insect pests may in this sense be worthy of consideration under the heading of "Changes in life range". But, although we do not question the importance of recording all the available data on the newly arrived insects, it seems to be not clearly related to the problem of changing life ranges, as we had this in mind. It is otherwise, however, with long-established foreign pests, such as San José Scale, whose northerly limit of distribution had been static but is now shifting northward. When I first became interested in life zones, many years ago, I regarded them as quite stabilized as far as the duration of a man's life time was concerned. But looking back over the sixty odd years since I began to collect insects at De Grassi Point, Lake Simcoe, I have witnessed the gradual decrease in numbers of some species that were once common, until they vanished altogether and I have seen other species, never known in that territory before, arrive there and in the course of time become firmly established. The species that disappeared were chiefly northern ones, whereas the newcomers were all from the south.

This last statement suggests a changing climate, that is becoming warmer. The probelm, however, is not quite as simple as it seems.

It is a well-known fact that many northern plants and insects reach their southern limits of distribution in the coolest available places, high in the mountains or in cool bogs and swamps. Such plants as the bunchberry, twin-flower and Labrador tea, are found in cool wooded swamps in southern Ontario, but are generally distributed northward. So it is also with the associated insects. Fifty years ago the northern bush-katydid, *Scudderia pistillata* (Brunner) was generally distributed in the Lake Simcoe region. Now it is limited to open marshes and there are other cases of species, once common, that have disappeared altogether.

But not all of these northern species can live in a swamp or a bog. Some, like the crackling, yellow-winged grasshopper, *Circotettix verruculatus* (Kirby), are partial to dry, sandy or stony habitats. In my early days of collecting at De Grassi Point, Lake Simcoe, I found this grasshopper commonly in many sandy barrens and particularly in a piece of waste land near Lefroy, in Simcoe County, which had been burned over many years before we first came to the region in 1890. In spite of this piece of property having remained waste land ever since and kept in much the same state by two or three small bush fires, *C. verruculatus* has disappeared entirely and from all the many scattered stations where it used to live, but it remains a common insect in Muskoka and northward.

Other kinds of grasshoppers have immigrated from the south, these immigrants first colonizing the drier and warmer areas. Very recently we have received from the south another bush-katydid, *Scudderia texensis* Saussure-Pictet, which was formerly known in Canada only from Point Pelee, where it was strictly an inhabitant of open marshes. But at Lake Simcoe it is living in open grassy fields, which are in no sense marshy.

Not only grasshoppers but many other native insects have been moving northward in a similar way in Ontario. Dr. Judd has mentioned a butterfly, the Buckeye, *Junonia coenia* (Hübner), among species of the Carolinian Zone in Ontario. This insect was an extreme rarity in the nineties, perhaps only a straggler from the United States, but in recent years it has become common not only about Toronto but even at Lake Simcoe.

The shifting ranges of these insects seem to be comparable to those of some of the mammals and birds mentioned by Dr. de Vos and Messrs. Bird, Miller, and Sheppard. Thus we have the retreat of the Mule Deer and the advance of the White-tailed Deer in Manitoba; the similar disappearance of the Woodland Caribou from most of its original range followed by the northward spread of the Moose and White-tailed Deer; the replacement of the Canada Lynx by the Bob-cat; and also the movements in extreme southern Ontario of the Opossum and the Badger; and finally the more familiar northward spread of the Cardinal, Turkey Vulture and other birds.

All of these seem to be examples of the same general trend, the shifting of life zones northward, a movement suggestive of a corresponding change from a cooler to a warmer climate.

QUESTIONS AND ANSWERS

Question: Professor D. M. Davies: "Mr. Chairman, I wonder what importance polyploidy has in increasing the ranges of plants and animals. It is known that certain plant groups have diploid species with restricte dranges whereas polyploid species evolving from them have a much increased range. The increasing range of these plants would influence the range of insects and other animals associated with them. I wonder what bearing polyploidy in animals would have on faunal ranges."

Dr. A. W. A. Brown.—The plant *Biscutella laevigata* L. is diploid in Germany but polyploid all over central Europe and Italy. A species of *Tradescantia* is diploid in Texas and tetraploid all over southern U.S.A. By and large, tetraploids can compete over a larger range than diploids. (We also have the very successful tetraploid rye from Germany, artificially induced). But tetraploids are rare in animals (*Drosophila* and *Ascaris* being the only well-known examples) and, as far as I know, have not been found in mammals.

In reflecting on this matter of northward extensions, one is struck by the fact that no northward extensions of trees are reported. In Soper's characterization of the trees of the Carolinian zone, mentioned by Dr. Judd, he assumes a static distribution of these trees, and there is no indication that they have recently spread northwards.

In some instances of northward spread generally, one must ascribe it to historical rather than climatic factors. For example the Spanish moss (*Tillandsia,* a member of the pineapple family, of all things) has recently extended its range into North Carolina and northern Georgia. This could be interpreted as a spread of subtropical conditions, but the truth is that in north Georgia the Spanish moss has survived temperatures of 10-15 below zero Fahrenheit. Moreover its spread is probably a historical matter; apparently from its origin in the Caribbean islands it is being distributed by hurricanes, and thus is carried further into North America.

Mr. W. J. Douglas Stephen: "Has a southern extension of faunal ranges occurred as well as those shown in a northward direction? Perhaps this extension has been a result of physiological changes which enable the species to survive in the new range."

Dr. A. W. A. Brown.—The panel has been so remarkably successful in marshalling its evidence for a general northward extension of ranges, that I feel something should be said on the other side. The gray fox has been quoted as a typically Carolinian animal; yet Wilfrid Jury has found, among the middens of the Midland settlement of the 17th century, more bones of the gray fox than of the red fox. Since I would rather see Guelph acquire the climate of Muskoka than that of Georgia, I should like to think that the peak of the warming up period was about 3,000 B.C., and that, as the calcium content of foraminiferous oozes has shown, the temperatures of the oceans at depths have been decreasing ever since, and that what we are now witnessing is just an ephemeral cycle.

The northward range extensions that the panel have cited have been so great that it would suggest another factor than climate is involved, namely genetic change. These range extensions (San Jose scale, European corn borer, European pine shoot moth) concern introduced insects. One would consider it not unlikely that if these highly heterozygous populations were exposed over a period of years to conditions of lower temperature, they would succeed in accumulating by Darwinian selection a genotype which imparts a lower temperature optimum and resistance to cold, in exactly the same way as, for example, the acquisition of resistance to DDT. Indirect evidence for just this is to be found in the study of *Drosophila melanogaster* Meigen in eastern Europe, where the southern populations have higher temperature optima and the northern populations lower temperature optima. When examined in the laboratory. Similar geographical genotypes may well be developing to allow range extensions into cooler climates in Canada.

SUBMITTED PAPERS

FIVE YEARS PROGRESS IN THE CONTROL OF WARBLE FLY IN ONTARIO 1951 - 1955

A. W. Baker[1] A. A. Kingscote[2] W. C. Allan[3]

INTRODUCTION

This programme really began in 1948 despite the fact that power spraying of cattle had been done in Goderich Township, Huron County in 1946 and in several townships in Bruce County in 1947. Results of this work were reported by the present authors in 1951 (1).

Power spraying of cattle has been carried on for many years in Western Canada and the Western United States with good results in many instances. Cattle in these areas are confined in chutes or crowding pens when being sprayed, while in Ontario young cattle, which carry the bulk of the larvae, are mostly sprayed in box stalls or loose boxes and no restraint of the animals is possible.

Since it was realized that power spraying for the control of warble flies was arousing considerable interest in the province and since it was not known whether control could be secured in Ontario by this method it was agreed that studies should be carried out.

ONTARIO WARBLE FLY COMMITTEE

Early in 1947 the Ontario Warble Fly Committee was established. This was made up of members of the Ontario Livestock Branch, the Department of Entomology and Zoology and the Department of Animal Husbandry of the Ontario Agricultural College, the Department of Parasitology of the Ontario Veterinary College and the Division of Entomology, Canada Agriculture.

Under the direction of this committee the results of the unsupervised power spraying programme in Goderich Township were studied. It was found that control was far from satisfactory. In order to determine if power spraying under Ontario conditions was feasible and practicable extensive trials with large numbers of cattle were carried out in 1948. The result of these studies established that satsfactory control by power spraying of young cattle in box stalls and loose boxes could be secured. It was established also that satisfactory control by hand scrubbing could be secured but here restraint of the animal was necessary.

CONTROL PROGRAMME

In order that a control programme might be properly applied it was obvious that the timing and number of treatments required would be of paramount importance. Accordingly biological studies were undertaken in the spring of 1948 to determine the time of appearance of the larvae in the backs of cattle and their peak of emergence.

These control and biological studies have already been reported (1).

WARBLE FLY CONTROL ACT

On the basis of these studies it was decided to establish a supervised control programme in Ontario under a revised Warble Fly Control Act.

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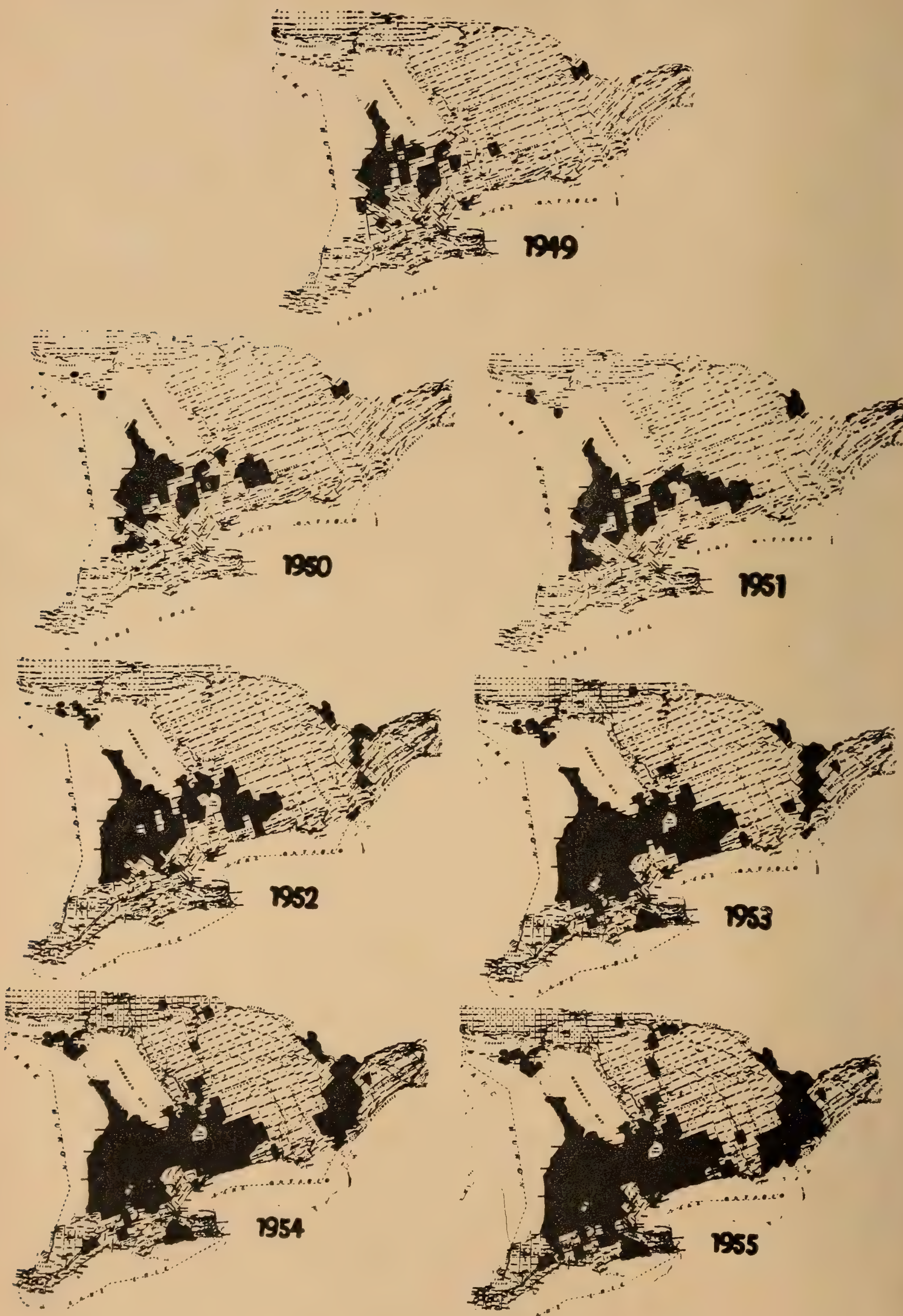
1949
1950
1951
1952
1953
1954
1955

This Act is enabling legislation. On the presentation of a petition signed by 66 2/3% of the cattle owners in a township the council of that township must pass a bylaw bringing the Act into effect. Since many more than the required number of cattle owners usually sign the petition the bylaw has public support from its inception.

GROWTH OF PROGRAMME

In 1948 only a few townships in southwestern Ontario, bordering on Lake Huron, carried on a control programme. In 1949 forty townships operated a programme under the Act. As neighbouring townships saw the results they also applied for legislation and so the programme spread across the province until in 1955, 247 townships in 36 counties or districts, an area covering many thousands of square miles, were under the Act. The maps in Fig. 1 show the spread across the province from 1949 to 1955.

ADMINISTRATION OF ACT

The Warble Fly Control Act is administered by the Livestock Commissioner for Ontario and the general control programme is under the Ontario Warble Fly Committee. One or more inspectors is appointed in each township to enforce the Act and Regulations. In 1955 over 300 such inspectors operated under the supervision of several provincial inspectors. The province subsidizes the townships to the extent of half of the salary and expenses of the township inspector or inspectors and half of the cost of the insecticide used.

In 1955 over 70,000 cattle owners were under the Act and a total of 1,364,200 head of cattle were treated. Public acceptance of the programme is evidenced by the fact that of over 60,000 cattle owners involved in 1954 only five were brought to court for non-compliance with the Act and Regulations.

METHODS AND MATERIALS

Under the Act and Regulations methods and materials required for power spraying and hand treatment are laid down. Under the Act either form of treatment is permitted.

Schools for inspectors are held annually. At these schools various problems are discussed and new inspectors are trained in the various phases of the programme and its enforcement. Spray machine operators, reeves and councillors are invited to attend these schools. Inspectors are provided with a manual for their guidance and with the various forms needed to report the results of their work.

INSTRUCTIONS

Detailed instructions for the treatment of cattle are set out in a previous paper (1).

It will be noted in these instructions that while the first treatment period extends from 1st to 18th April, the second treatment period is a much longer time namely 1st to 31st May. The reason for this increase in time is to make sure that cattle coming into a township under the Act from an untreated area up to 31st of May must be treated as laid down in the Act.

NUMBER OF TREATMENTS

Three treatments as mentioned above would be ideal but only two as outlined are required under the Act. This is due to conditions in the beef cattle industry in Ontario. Most beef cattle in the province go to grass early in May—often to large grass farms or ranches where they are inaccessible for treatment.

RESULTS

At the beginning of this work untreated herds in southwestern Ontario showed a population, in young animals, of 12 to 15 grubs per head. The application of the control programme has reduced this in many townships to a fraction of a grub per animal and in many areas

"gadding" has practically disappeared. Continuous vigilance on the part of inspectors to ensure thorough treatment is required. Poor treatment in a township even for only one year will permit the population to increase the next year.

ANNUAL SURVEYS

Teams are sent out each spring to check the grub population in the young cattle in selected townships. Farms are selected at random in each township and the grubs are counted in the backs of each young animal. At least one hundred animals are checked in each townsrip.

The results of these annual surveys show, in general, an encouraging reduction in the grub population across the province. In many townships where the treatment has been thorough there has been a progressive drop in the population. All townships obviously cannot be surveyed each year so a random selection is made. In some cases, however, either because of good or poor results townships may continue to be included in the survey. It is obvious that a high or increasing count may be indicative of less efficient treatment. This enables provincial inspectors to determine the areas in which they must exert their greatest efforts.

Since Goderich Township was the first treated a survey has been carried out there each year. Table 1 gives the results since 1948.

TABLE I

WARBLE GRUB POPULATION STUDIES

Area	Year	Animals examined	Total grubs	Average grubs per animal
Goderich Township	1948	287	2625	9.2
	1949	368	2363	6.2
	1950	314	1827	5.8
	1951	394	1347	3.4
	1952	503	1189	2.4
	1953	271	262	0.9
	1954	200	175	0.9
	1955	138	91	0.7

Bruce County was the first in the province in which all townships came under the Act. For this reason surveys have been carried on more continuously in Bruce than in other counties. With the exception of three townships the satisfactory downward trend seen in Goderich Township has been maintained. Even in these townships there is a great reduction from the original population.

TABLE II

AVERAGE NUMBER OF GRUBS PER ANIMAL FOUND IN YOUNG CATTLE IN SIX TOWNSHIPS IN BRUCE COUNTY 1948-55

Township	1948	1949	1950	1951	1952	1953	1954	1955
Brant	9.1	7.5	3.6	0.8	1.5	2.3	2.9	—
Bruce	12.7	21.4	3.8	0.0	0.8	0.5	2.2	1.6
Carrick	8.9	10.2	3.8	5.2	3.4	1.2	2.5	3.4
Culross	8.9	8.1	3.4	3.3	1.9	1.8	1.8	—
Eastnor	6.2	9.8	1.5	1.6	—	—	—	—
Greenock	12.0	8.3	1.7	0.1	0.9	—	—	1.2

Although a higher kill can be secured by hand treatment than by power spraying, good results may not be obtained in a township where treatment is entirely or largely done by hand by the cattle owners themselves. This of course is due to the human element and the wide variation in thoroughness and efficiency which exists among several hundred individuals.

Dufferin County has been largely hand treated over a period of several years. The survey results in Table III show that, in general, the grub population has not been reduced as it has in most power sprayed townships.

TABLE III

AVERAGE NUMBER OF GRUBS PER ANIMAL FOUND IN YOUNG CATTLE IN SIX TOWNSHIPS IN DUFFERIN COUNTY 1951-55

Township	1951	1952	1953	1954	1955
Amaranth	7.5	7.1	4.7	4.7	5.1
East Garafraxa	10.4	8.1	3.6	6.5	4.1
East Luther	—	7.7	3.7	4.6	3.8
Melancthon	—	5.7	4.4	6.3	6.5
Mono	6.5	4.1	9.3	3.4	4.9
Mulmur	—	4.9	4.2	4.3	1.9

SUMMARY

Those concerned with the administration of this programme in Ontario over a nine year period are satisfied that the warble fly population and "gadding" of cattle have been greatly reduced. Hides from areas which have been under the Act for several years show a great improvement in quality.

It must be emphasized however that continued vigilance in the enforcement of the Act and Regulations is essential if improvement is to continue. As indicated in Table III even one year of poor treatment will mean an increase in population. Conditions in Ontario are further complicated by the continual importation of infested western cattle as feeders and stockers. This means that our control programme can never be slackened.

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CONTROL OF WIREWORMS IN EARLY POTATOES WITH HEPTACHLOR APPLIED TO THE SOIL AFTER PLANTING[1]

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Widespread use of wireworm control measures (1, 2) in recent years has resulted in a marked improvement in the quality of potatoes grown in Ontario. Various organic insecticides incorporated into the soil before planting protect the tubers satisfactorily and practically eliminate the wireworms (1). In general, less insecticide is required and better protection is provided when the treatment is applied in the year before the potatoes are grown.

[1]Contribution No. 3412, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada; presented at the annual meeting of the Entomological Society of Ontario, Guelph, October 31-November 2, 1955.

[2]Assistant Entomologist.

Occasionally, growers plant potatoes in infested soil and only become concerned with the problem when the seed pieces are attacked. Treatments applied after planting had not previously been investigated. This is a report on an experiment conducted in 1955 on row and broadcast treatments with heptachlor applied at various times after planting for emergency control of wireworms.

METHODS AND MATERIALS

Irish Cobbler potatoes were planted on April 12 and 13, 1955, in a field of Berrien sand that was infested with the eastern field wireworm, *Limonius agonus* (Say). The treatments were applied 10, 20, and 34 days after planting. Plots three rows wide were replicated four times. To minimize contamination a buffer row was left on each side of plots receiving the broadcast treatment.

Row treatment

Two and a half per cent granular heptachlor* (Velsicol Corp., Chicago, Ill.) at 2.0 lb. of toxicant per acre was applied with a fertilizer side-dresser at a depth of 4 to 6 in. on both sides of the potato row. Each band was approximately 1½ in. wide. Treatments made 10 and 20 days after planting were applied 4 in. from the row; that at 34 days, 6 in.

Broadcast treatment

An emulsifiable concentrate (Heptachlor 2E, Velsicol Corp.) at 3.65 lb. of toxicant per acre was applied with a power sprayer adjusted to apply approximately 50 gal. of water per acre. Immediately after application the insecticide was worked into the soil to a depth of 4 to 6 in. with a single-row cultivator. This cultivation was carried out as close to the potato row as considered safe.

Yields were taken by weighing the potatoes of Canada No. 1 grade size that were harvested from 50 plants selected at random in the centre row of each plot.

All feeding scars that went through the skin of the potatoes were counted in assessing the wireworm injury. Other workers had considered only the holes a quarter of an inch or more in depth (6). Commercial control was assumed when 95 per cent or more of the tubers were of Canada No. 1 grade, those with no more than one hole being classed as of No. 1 grade in respect to wireworm injury.

Wireworm population counts were made after harvest. Five 1-ft. cubes of soil dug at random in the centre row of each plot were sifted through a screen with quarter-inch mesh.

RESULTS AND DISCUSSION

Table I shows that each of the treatments gave 89 per cent or more No. 1 tubers, the difference in method of application being significant when tested against the interaction term (treatment x time) by analysis of variance. However, only the row treatment applied 10 or 20 days after planting gave commercial control (95 per cent No. 1 grade).

Each treatment reduced the wireworm population significantly (Table I). However, the number of wireworms associated with commercial control was 17,424 or fewer per acre (0.40 or fewer per cu. ft.). Roebuck (7) considered that a population of 50,000 per acre would cause negligible injury, but Hawkins (4) found that 10,000 or fewer wireworms per acre caused 201 to 400 punctures per 100 potatoes in 6 of 34 plots.

Testing the treatments against the interaction term (treatment x time) showed that there were significant differences in the reduction in population afforded by the two treatments, and in the times of application. Greenwood (3), experimenting with BHC, found that row treatments applied as potatoes were planted appeared to be a more effective method of application than a broadcast treatment.

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*1, 4, 5, 6, 7, 8, 8-heptachloro-3a, 4, 7, 7a-tetrahydro-4, 7-methanoindene.

TABLE I

Percentages of No. 1 Grade Potatoes and Average Numbers of Wireworms Per Cubic Foot for Row and Spray Treatments With Heptachlor Applied at Various Times After Planting, Highgate, Ontario, 1955

Treatment	Days after planting	Percentage No. 1 grade potatoes	Transformed value[1]	Wireworms per cubic foot	Transformed value[2]
Row, 2 lb. per acre	10	95.47	78.49	0.25	1.216
	20	95.77	80.69	0.40	1.547
	34	93.42	75.86	0.45	1.553
Spray, 3.65 lb. per acre	10	91.19	73.56	0.45	1.636
	20	92.04	74.64	0.95	2.204
	34	89.06	71.61	0.95	2.132
Check	—	52.39	47.01	2.85	3.427
Difference necessary for significance at the 5 per cent level (on basis of interaction term)				3.91	.481

[1]Inverse sine transformation was used.
[2]The transformation $y = \sqrt{1/2 + x}$, where x is the number of wireworms counted, was used.

The treatments applied 10 and 20 days after planting did not seriously disturb the potato seed pieces. Those made 34 days after planting, however, uprooted a few plants, which were replanted. In neither case was the yield of No. 1 grade potatoes affected.

Controlling wireworms after potatoes are planted offers a difficult problem. A treatment cannot be applied closer than 4 in. to the seed pieces, in which the wireworms are concentrated. Larvae that stay near the seed pieces, or move vertically, are relatively unaffected by the insecticide. Larvae moving horizontally, however, may come in contact with the treatment. Olson (5) showed that the eastern field wireworm moves rapidly to newly planted potatoes, but that by late July only a small percentage remains in the hill in position to damage the tubers. A second movement to the hill occurs in August. Larvae leaving and returning to the potato row may be affected by a treatment applied on either side of the row. Thus, the effectiveness of a row treatment depends largely on the larval activity during the growing season.

Although only heptachlor was used in this experiment, it is likely that other organic inescticides known to control wireworms would be effective when similarly applied.

SUMMARY

Heptachlor as a row treatment at 2.0 lb. per acre was more effective than as a broadcast treatment at 3.65 lb. when applied after planting for the emergency control of wireworms attacking early potatoes. Applications made 10 and 20 days after planting did not seriously disturb the seed pieces, but at 34 days some plants were uprooted. The row treatment should be applied on both sides and as close as possible to the potato seed pieces.

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NOTE ON AN OUTBREAK OF THE EUROPEAN FRUIT LECANIUM, *LECANIUM CORNI* (BOUCHE) (HOMOPTERA:COCCIDAE), IN 1955 IN ESSEX COUNTY, ONTARIO[1]

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HISTORICAL

Lecanium corni (Bouché), according to McDaniel (7), occured in alarming numbers throughout the northern United States during the latter part of the nineteenth century and for a year or two in the twentieth. I was known then as the New York plum scale, and caused considerable injury to plum in New York State. Jarvis (6), in 1911, reported this scale as common in Ontario and Quebec, and listed 57 species of trees, shrubs, vines, and herbs as hosts.

Caesar and Ross (3) reported *L. corni* as particularly abundant on plum, especially Japanese varieties, in the Niagara district during 1925. Ross and Putman (8), in 1934, stated that a scale, which probably was *L. corni,* was common on peach in Niagara but that it had never assumed serious proportions on this host.

FEATURES OF THE CURRENT OUTBREAK

On August 17, 1955, a heavy infestation of a 20-acre block of Halehaven and Kalhaven peaches at Ruthven, Ontario, by a scale insect was brought to my attention. Specimens were identified by Mr. W. R. Richards, Entomology Division, Ottawa, as of *Lecanium corni* (Bouché).

A survey of the district surrounding the heavily infested orchard, in which 30 per cent of the fruit was rendered unmarketable by discoloration from growth of sooty mold fungus in excretions from the scale, showed *L. corni* to be present in seven other orchards, one of which was four miles distant. In these orchards damage to the fruit varied from a trace to approximately ten per cent, and scale populations were much lower.

A striking feature of the infestation when first observed was that mature scales with eggs and hatching larvae, as well as newly established larvae, were present on 1955 wood, leaf petioles, and lower surfaces of leaves. Since *L. corni* normally hatches during late June and early July and, as mature scales with eggs or hatching nymphs were present on 1955 wood and leaves, there was strong circumstantial evidence that a second generation of the scale occurred in 1955.

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[1]Contribution No. 3400, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada; presented at the annual meeting of the Entomological Society of Ontario, Guelph, October 31-November 2, 1955.
[2]Entomologist.

Ebeling (4), Fenton (5), McDaniel (7), and Suter (9) each stated that *L. corni* has one generation per year. Asquith (1, 2) reported the occurrence of two generations of this scale in Pennsylvania during 1948 and 1949. Previously there had been no evidence of more than one annual generation of *L. corni* in Ontario. These differences in statements concerning the number of generations per year suggest that there have been errors in identification of the species concerned, or that bivoltine races of *L. corni* may be evolving in eastern North America, or that exceptionally warm seasons such as 1955 favour the development of a second generation.

The reason for the current outbreak in Essex County is not known. Asquith (1) suggested DDT and possibly BHC as factors in the sudden outbreak of the European fruit lecanium in Pennsylvania through reduction of natural enemies. As DDT has been used extensively in Essex County peach orchards since 1948, it may have been a factor in the present outbreak. It appears peculiar that the severe infestation in Pennsylvania occurred approximately three years after the use of DDT began, yet the current outbreak in Ontario did not occur until seven years after the beginning of general use of DDT against the oriental fruit moth in peach orchards.

In the severely infested orchard in 1955 examination of 1500 adult scales at mid August failed to indicate the presence of any parasites. Treherne (10), in 1915, reported 14 species of chalcids and one proctotrupid as parasites of *Eulecanium cerasifex* Fitch and *Eulecanium fitchii* Sign., both of which are considered to be synonymous with *L. corni*. In view of the great number of native hosts of *L. corni* and the number of parasites listed, it seems possible that DDT may have caused serious mortality of parasites of this scale in peach orchards, or that a general catastrophe to the natural enemies may have occurred in Essex County.

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EXPERIMENTS ON CONTROL OF THE STRAWBERRY LEAF ROLLER, *ANCYLIS COMPTANA FRAGARIAE* (W. & R.), IN NORFOLK COUNTY, ONTARIO[1]

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INTRODUCTION

The strawberry leaf roller, *Ancylis comptana fragariae* (W. & R.), has been a common pest of strawberry in North America for more than half a century. In recent years severe infestations have become general throughout Norfolk County, Ontario.

For many years lead arsenate and calcium arsenate (1) and cryolite were recommended for the control of this insect but none of these was very effective. More recently parathion and DDD have been recommended in New York State, and parathion has been used to a limited extent in Ontario.

During 1954 and 1955 several of the newer insecticides were tested in bearing and non-bearing fields in Norfolk County against both newly hatched and nearly mature larvae.

MATERIALS AND GENERAL METHODS

The following insecticides were tested, as sprays or as dusts: parathion, malathion, Diazinon, DDD, DDT, aldrin, endrin, methoxychlor, ryania, and lead arsenate. Those applied in various experiments and the rates and numbers of applications are given in the tables.

Premier was the variety of strawberry used throughout.

The sprays were applied with hand guns fitted with a number five disc. The guns were attached by a hose line to a power-driven pump operating at 200 p.s.i. The pump and a 40-gallon tank were mounted on a jeep, which straddled the rows without injuring the plants. Plants were sprayed to the point of run-off, approximately 200 gallons per acre being used. As the tests in 1954 indicated that a second application gave little or no added control, only single applications were made in 1955.

Except in the tests against older larvae, the plots were arranged in randomized blocks and each treatment was replicated four times.

The effects of the early-season tests were determined by counting the living larvae on 20 plants in each plot. In some of the later tests, individual plants became hard to distinguish and counts were made on all plants per ten yards of row. In addition, the number of runners developing on a total of 50 plants per plot was recorded.

CONTROL OF THE FIRST GENERATION

Eight treatments, including an unsprayed check, were tested in plots each containing seven rows 45 feet long in a heavily infested field. In 1954, the first spray was applied on June 9, when the first eggs were on the point of hatching. A second spray was applied to some plots on June 21. In 1955 the application was made at the peak of hatching, on June1.

Results of the 1954 tests are given in Table I. Analysis of variance, using the log $(x + 1)$ transformation, showed that three treatments, namely, DDD (2 applications), DDD (1 application), and malathion (2 applications), were significantly better than the other treatments at the one per cent level, but not significantly different from each other.

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[1]Contribution No. 3423, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada; presented in part at the joint meetings of the Entomological Society of Canada and the Entomological Society of Ontario, Sault Ste. Marie, November 1-3, 1954, and at the annual meeting of the Entomological Society of Ontario, Guelph, October 30-November 2, 1955.
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[3]Officer-in-Charge.

TABLE I

Average numbers of living first-generation larvae of the strawberry leaf roller on July 9 and numbers of runners produced on plants by late July after one or two applications of a wettable powder of each of various insecticides, 1954

Material per 100 gallons per half acre	No. of applications	Larvae per 20 plants per plot Average	Larvae per 20 plants per plot Log $(x+1)$	Runners per 50 plants per plot Average	Runners per 50 plants per plot Log $(x+1)$
50% DDD, 2½ lb.[2]	2	.5	0.1193	213.2	2.3302
50% DDD, 2½ lb.	1	7.0	0.8329	160.5	2.2019
25% malathion, 2½ lb.[3]	2	12.5	1.0778	164.2	2.2135
25% malathion, 2½ lb.	1	62.0	1.7569	188.2	2.2763
20% aldrin, 2½ lb.[4]	2	193.5	2.3555	94.7	1.9718
Lead arsenate, 5 lb.[5]	1	237.0	2.3659	148.2	2.1624
20% aldrin 2½ lb.	1	267.0	2.4257	94.0	1.9545
Check, unsprayed	0	337.0	2.5257	106.2	2.0293
Difference necessary for significance					
at 1% level			0.4284		0.2637
at 5% level			0.315		0.1938

[1]First application on June 9, and the second on June 21.
[2]Rohm & Haas Company, Washington Square, Philadelphia, Pa.
[3]American Cyanamid Company, 30 Rockefeller Plaza, New York, N.Y.
[4]Shell Oil Company of Canada Ltd., Agricultural Chemicals Division, 25 Adelaide St. East, Toronto 1, Ont.
[5]Niagara Brand Spray Company, Burlington, Ont.

Results of the 1955 tests are given in Table II. Analysis of variance showed that all treatments were significantly better than the check at the one per cent level. Parathion, Diazinon, DDD, and malathion were significantly better at the one per cent level than methoxychlor, and ryania.

TABLE II

Average numbers of living first-generation larvae of the strawberry leaf roller on June 14 after one application of a wettable powder of each of various insecticides, 1955

Material per 100 gallons per half acre	Larvae per 20 plants per plot Average	Larvae per 20 plants per plot Log $(x+1)$[1]
15% parathion, 2 lb.[2]	0.5	0.1192
25% Diazinon, 2 lb.[3]	0.7	0.1505
25% malathion, 2 lb.	2.5	0.4203
50% DDD, 2 lb.	2.5	0.4955
50% methoxychlor, 2 lb.[4]	17.75	1.2651
100% ryania, 6 lb.[5]	20.5	1.3298
Check, unsprayed	113.75	2.0573

[1]Difference necessary for significance at 1% level: 0.5773; at 5% level: 0.4243.
[2]N. M. Bartlett Manufacturing Company, Beamsville, Ont.
[3]Geigy Agricultural Chemicals, 89 Barclay St., N.Y.
[4]E. I. du Pont de Nemour & Co. (Inc.), Agricultural Chemicals Division, Wilmington Co., Del. (Marlate).
[5]S. B. Penick & Company, New York, N.Y.

Towards the end of July, 1954, the numbers of runners in plots treated with malathion and DDD were significantly greater than for the other plots (Table I). Although most treatments increased the number of runners, the increase was not always proportional to the reduction in numbers of leaf rollers.

CONTROL OF THE SECOND GENERATION

Seven insecticide formulations applied on August 11, 13, and 17, 1954, were compared in a second strawberry field where no control of the first generation had been attempted.

The plots each contained four rows 105 feet long. The materials, rates of application, and results on the basis of the number of living larvae on ten yards of row in each plot on August 24 are given in Table III.

TABLE III

Average numbers of living second-generation larvae of the strawberry leaf roller on August 24 after an application of each of various insecticides, 1954

Material	Rate[1]	Living larvae per 10 yd. of row Average	Log $(x+1)$[2]
15% parathion w.p.	2 lb./100 gal.	8.5	0.9390
50% DDD w.p.	2 lb./100 gal.	19.5	1.3027
7% DDD dust	25 lb./acre	25.25	1.4042
50% malathion emul.	2½ lb./100 gal.	68.75	1.8239
50% DDT w.p.	2 lb./100 gal.	84.75	1.8940
25% malathion w.p.	2 lb./100 gal.	86.75	1.9181
20% endrin emul.	½ pt./acre	108.5	2.0335
Check		220.0	2.3401

[1]About 200 gallons per acre.
[2]Difference necessary for significance at 1% level: 0.4492; at 5% level: 0.6112.

All the treatments were significantly better than the check. Parathion and DDD dust and wettable powder gave significantly better control than the other insecticides. Malathion emulsion was more effective than the wettable powder and significantly better than DDT and endrin, which were comparatively ineffective.

Tests of Several Dose Rates of DDD

An experiment was conducted to determine the optimum dose of DDD for control of the second generation in unreplicated plots in a small, heavily infested field. Each plot contained four rows 400 feet long. The treatments were applied on August 3. The amounts of DDD used and the number of surviving larvae were as follows:

Lb. of 50% DDD per 100 gal.	4	2	1	0.5	0
No. of living larvae per 10 yd. of row	10	24	68	129	362

These results suggest that good control may be expected from 2 pounds of 50 per cent wettable powder per 100 gallons of water. The additional reduction in numbers given by 4 pounds was not sufficient to justify the extra material.

Control of Established Older Larvae

Five treatments were applied against larvae of the second generation in the second to late-fifth instars, some of the latter being close to pupation. The pretreatment infestation was approximately five larvae per plant. These treatments were not replicated. Each plot was 200 feet long and four rows wide. The treatments were applied on August 3.

All treatments reduced the infestation to insigificant numbers. Fifteen per cent parathion, 25 per cent Diazinon, and a combination of 50 per cent DDD and 25 per cent malathion, all at 2 pounds of the wettable powder per 100 gallons, gave 100 per cent reduction. DDD or malathion used alone was less effective.

DISCUSSION AND SUMMARY

The tests on the newly hatched larvae in 1954 and 1955 showed that parathion provided satisfactory control of the strawberry leaf roller when applied during the second week in June. Of the newer insecticides tried in 1955, Diazinon was equally as good. The present

prohibitive cost of Diazinon is its major drawback. The value of controlling the first generation in first-year plantings is indicated by the increased number of runners after the treatments.

The tests on established older larvae showed that parathion, Diazinon, and malathion-DDD provided 100 per cent control, but that DDD and malathion used separately were somewhat less effective. The concentration tests with DDD indicated that two pounds actual per acre was a satisfactory rate.

The tests conducted to date suggest that a grower may achieve satisfactory control of established larvae of any age with parathion, Diazinon, malathion, or DDD.

ACKNOWLEDGMENT

The writers wish to thank H. Wagner, of the Simcoe laboratory, for his management of the spray equipment; R. R. Lipsit, district fieldman of the Ontario Department of Agriculture, for his helpful suggestions and assistance, and the various growers who cooperated in carrying out the work. Appreciation is expressed to G. G. Dustan, Entomology Laboratory, Vineland Station, Ont., H. R. Boyce, Science Service Laboratory, Harrow, Ont., and E. J. LeRoux, Science Service Laboratory, St. Jean, Que., for their constructive criticism of the paper.

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OBSERVATIONS, LIFE-HISTORY, HABITS, IMMATURE STAGES, AND REARING OF *LOXOTROPA TRITOMA* (THOMS.) (HYMENOPTERA: PROCTOTRUPOIDEA) A PARASITE OF THE CARROT RUST FLY, *PSILA ROSAE* (F.) (DIPTERA: PSILIDAE)[1]

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Between 1949 and 1954, puparia of the carrot rust fly, *Psila rosae* (F.), were imported from England to obtain two species of parasites, *Loxotropa tritoma* (Thoms.) and *Dacnusa gracilis* (Nees), for release in Canada. These species were reported as occurring in considerable numbers on *P. rosae* in England (12). The puparia were incubated in the laboratory in a moistened mixture of soil and shredded sphagnum moss at a temperature of 23.9°C. *L. tritoma* has a single generation a year on *P. rosae* and overwinters in the first instar in host puparia (12). During the present investigation, adults of a partial second generation of *L. tritoma* emerged from the same lot of host puparia three weeks after the first. This was the result of the fact that some of the early-emerging females of *L. tritoma* had parasitized host puparia that had completed diapause and that had not been attacked previously. In host puparia in which diapause had been satisfied, *L. tritoma* developed without diapause (5). For continuous development of the parasite in the laboratory, it was therefore necessary to use host puparia that had completed diapause or to find an acceptable host that did not undergo diapause. Simmonds (10) reared a species of *Loxotropa* that attacks *Oscinella frit* (L.) on *Drosophila melanogaster* Mg. This proved an acceptable host for *L. tritoma*. The life-history and habits and the technique for rearing *L. tritoma* on *D. melanogaster* are described in this paper.

[1]Contribution No. 3416, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada.

[2]Assistant Entomologist.

DISTRIBUTION AND HOSTS

The genus *Loxotropa* has a wide geographical distribution, as it is represented in most of Europe, North America, and the West Indies (4). Species are also found in Java, New Guinea, the Seychelles, the Phillipines, Central Africa, and Egypt. Members of the genus are generally parasitic on dipterous larvae. Donisthorpe (2) listed *L. tritoma* among the species found in ants' nests, probably as a parasite of Diptera that live in association with the ants. *L. tritoma* is recorded as a parasite of *O. frit* in Germany (6), in Russia (11), in England (4), and in Switzerland (8). It is widespread in East Anglia, England, as a parasite of *P. rosae* (12).

NOTES ON IMMATURE STAGES

L. tritoma lays a microtype egg in the haemocoele of the host pupa. The egg has not been previously described. It is ovate-oblong in shape, slightly narrowed posteriorly. It has an average length of 0.21 mm. and an average width of 0.07 mm. The chorion is smooth and transparent and the yolk is translucent. The larval instars were described by Wright, Geering, and Ashby (12). The first stage is easily recognized by the enlarged head capsule, the prominent, curved mandibles, and the two lateral protuberances on the last abdominal segment. It begins feeding on the host tissue soon after eclosion. Both first- and second-instar larvae float freely in the haemocoele, surrounded by smoky-coloured, viscid, host tissue. The head of the second-instar larva is poorly developed and bears a pair of conical antennae. The mouth parts are in the form of fleshy mandibular and maxillary lobes. There are no lateral protuberances on the last abdominal segment. When fully grown, the third stage almost fills the host puparium and its orientation parallels that of the host. The antennal lobes are pointed and the mandibles are pointed and strongly sclerotized. Before the gut contents are excreted, a complete cocoon is spun. This is contrary to the statement by Clausen (1) that hymenopterous parasites do not spin cocoons in dipterous puparia, but agrees with that of Monteith (7), who found that *Phygadeuon trichops* Thoms. spun a full cocoon in the puparium of *Hylemya* spp.

MATERIALS AND METHODS

Rearing of Host

D. melanogaster and *L. tritoma* were reared in the laboratory at 23.9°C. and 50-60 per cent relative humidity. The medium on which the host was reared was composed of the following ingredients in the amounts listed:

Water	433.0 cc.	Tomato juice	247.0 cc.
Agar	8.9 gm.	Cornmeal	57.0 gm.
Dextrose	20.0 gm.		

The water was heated and the other ingredients were added in the order given. The mixture was stirred gently, brought to a boil, and poured while fluid into petri dishes. After each culture had set, it was sprinkled with brewers' yeast and exposed to approximately 100 flies in a lantern globe for three days. The amounts listed above were sufficient for 10 petri dish cultures and two cultures in milk bottles to maintain a stock of flies. After each culture was removed from a colony of flies, it was covered with a moistened 9-cm. filter paper in a petri dish top. The fruit fly maggots began pupating on the filter papers after 24 hours. When overcrowding of larvae was apparent, the surplus was transferred to other cultures to avoid mortality or a prolongation of the larval period and the formation of small pupae (9).

Rearing of Parasites

Parasitism of host puparia was obtained by exposing them to adults of *L. tritoma* in museum jars (Fig. 1). Ten filter papers, each bearing approximately 175 puparia, were exposed in a jar for 24 hours to approximately 400 parasites. The complement of parasites was maintained by adding fresh adults weekly but overstocking was avoided in order to minimize superparasitism. To hold the filter papers bearing the puparia, a rack was made of acrylic resin

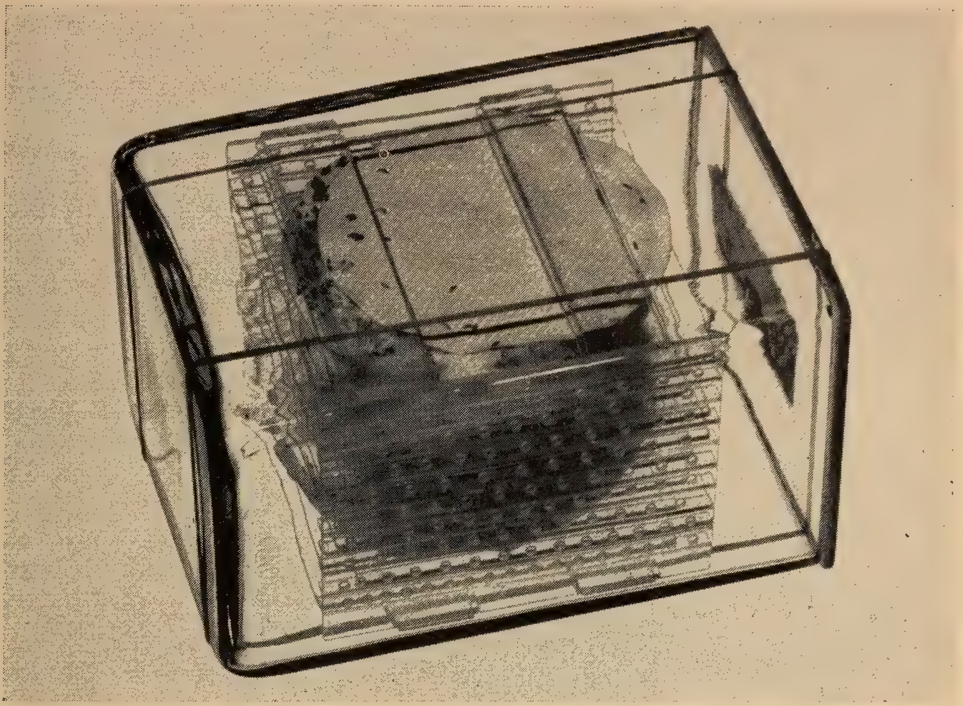

Fig. 1. Museum jar for rearing *Loxotropa tritoma* (Thoms.) in the laboratory on *Drosophila melanogaster* Mg.

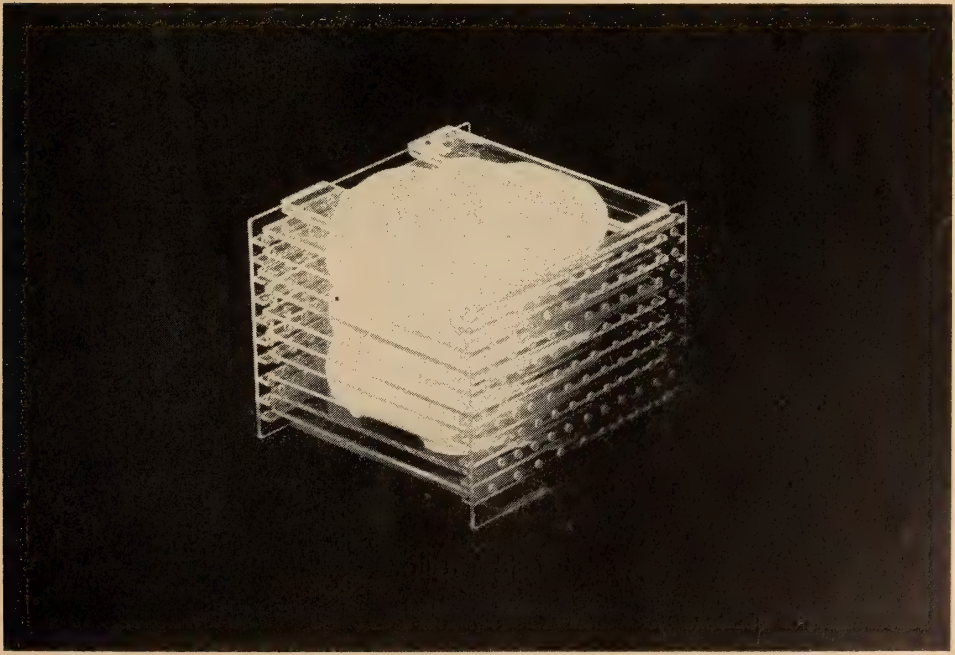

Fig. 2. Rack with removable shelves used in rearing *L. tritoma* in the laboratory on *D. melanogaster*.

sheeting, 1/16 of an inch thick. This consisted of solid sides with straps of the same material on which rested removable shelves, 3¾ inches square, which in turn carried the filter papers (Fig. 2). To prevent trapping the parasites between the sides of the museum jar and the solid sides of the rack, holes were bored in the latter between the shelf supports. The museum jars had ground edges and lids to make a tight seal, and for ventilation two half-inch holes were made in the lids and covered with fine nylon cloth (Fig. 3). A few split raisins and short lengths of moistened dental cotton were placed in each jar to provide food and moisture. The rearing was done in darkness as *L. tritoma* usually hides in crevices away from light.

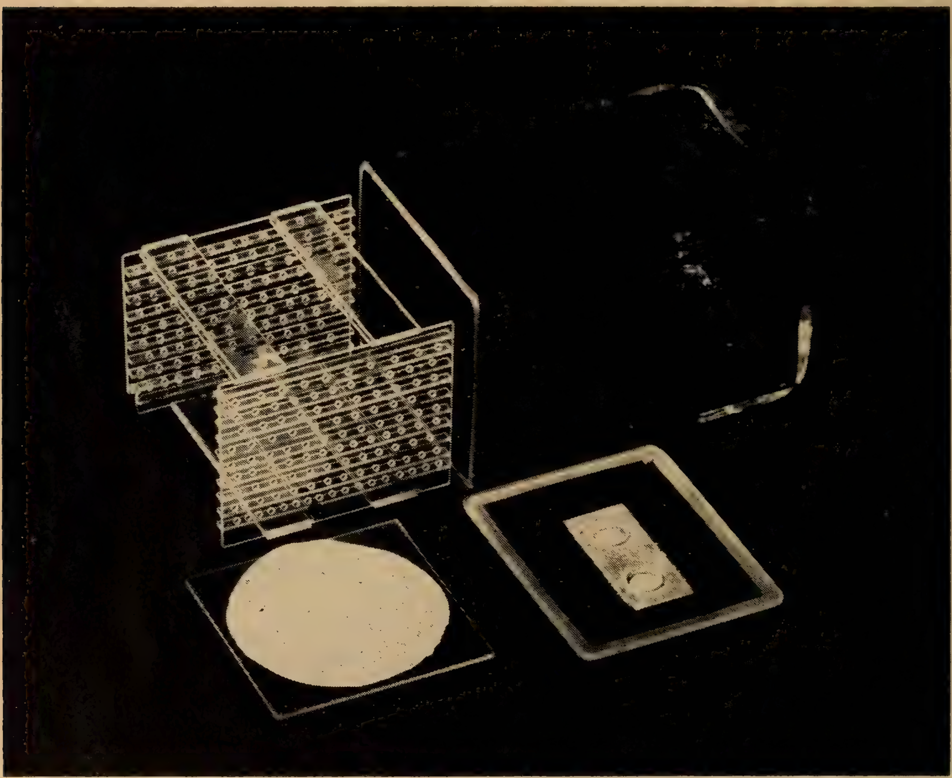

Fig. 3. Museum jar, lid, and rack used in rearing *L. tritoma* in the laboratory on *D melanogaster.*

The host puparia were incubated for 10 days after removal from the rearing jars to enable flies to emerge from unparasitized puparia. The parasitized puparia were placed for the remainder of the incubation period in 125-ounce jars. Parasites emerged between the 21st and the 36th day, with a peak in numbers at the 28th to the 30th day. An emergence of 1000 per day was attained by the daily exposure of 10 filter papers of host puparia to 400 mated females in each of four rearing jars. On emergence, the parasites were collected and stored in pint milk bottles at 6.7°C. until required for biological studies or release in the field. A length of slightly moistened dental cotton was added to each storage bottle. Parasites stored for four weeks suffered no significant mortality.

LIFE-HISTORY AND HABITS

The life-history and habits of *L. tritoma* were studied after the technique for rearing the insect in the laboratory had been developed.

Oviposition

Observations on 16 females showed that the average pre-oviposition period was 10.3 hours, the range being from one to 24 hours. The average time required to oviposit, based on 25 observations, was between eight and nine minutes, the range being from three to 16 minutes. The average number of eggs laid per female was 27.31, the great number by one female being 46 and the smallest 15. The number of eggs laid per female per day ranged from one to eight. The average duration of the oviposition period was 10.37 days; the longest was 17 days and the shortest six. Most of the eggs were laid during the first six days.

Superparasitism

The many dissections made during the study revealed the occurrence of superparasitism. The term is used here in the sense suggested by Imms (3), to denote the incidence of more than one parasite of the same species in one host. To find the effect of superparasitism on the development of the parasite, *D. melanogaster* puparia were presented to mated females in the ratio of 1:1 and dissections were made after various periods of incubation. The parasite developed to the third instar in only one of 139 puparia examined. Up to seven first-instar larvae were found in a single puparium. No emergence occurred and no living parasites were found on dissection in a group of 25 *D. melanogaster* puparia each of which was known to be parasitized more than once and incubated in a vial for 95 days. This indicates that the parasites do not emerge from superparasitized puparia.

Life-History in the Laboratory

The durations of the stages of development of *L. tritoma* in the laboratory when reared on *D. melanogaster* were found by dissecting host puparia after various periods of incubation at 23.9°C. The eggs hatched in about three days. The duration of each instar was ordinarily from 3.5 to 5 days. In 950 dissections, 204 larvae remained in the first instar for an average of 14.88 days; one active first-instar larva was found after 60 days' incubation. In *P. rosae, L. tritoma* enters diapause in the first instar (12); the prolongation of the first instar when *L. tritoma* is reared on *D. melanogaster* may be related to this diapause. *L. tritoma* spent about one day in the prepupal stage and from 10 to 11 days as a pupa. The average duration of adult life of 221 insects observed was 18.3 days for females and 17.9 days for males, with maxima of 36 to 34 respectively.

SUMMARY

A technique for rearing *Loxotropa tritoma* (Thoms.), a parasite of the carrot rust fly, *Psila rosae* (F.), in the laboratory on *Drosophila melanogaster* Mg. is described. Parasites emerged from the 21st to the 36th day after exposure of host puparia to parasites, with the peak in numbers at the 28th to the 30th day. Rearing was done at 23.9°C. and 50-60 per cent relative humidity. The average pre-oviposition period was 10.3 hours and the average oviposition period was 10.37 days. The average number of eggs laid per female was 27.31. The eggs hatched in about three days. From 3.5 to 5 days were spent in each instar, one day in the prepupal stage, and from 10 to 11 days as a pupa. No parasites emerged from superparasitized puparia.

ACKNOWLEDGMENTS

The autor wishes to thank officers of the Belleville laboratory: Mr. George Wishart for helpful criticism, Mrs. Helena Clarke for assistance in the rearing, and Mr. T. Stovell for technical assistance.

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FUMIGATION RESEARCH EQUIPMENT AT THE LONDON SCIENCE SERVICE LABORATORY[1]

H. A. U. Monro[2] and C. T. Buckland[3]

INTRODUCTION

Poison gases still hold an important place in the arsenal of weapons directed against harmful insects and pathogenic organisms. In common with many other developments in applied biology, the history of the use of fumigants has been that of their extensive application to meet pressing economic problems before very much was known about their mode of action or their ultimate effect on the components of the environment in which they were applied.

Fumigation research is a cosmopolitan endeavour and, in general, ideas or techniques worked out in one country can be applied in other parts of the world. Nevertheless, in different countries there are particular problems engendered by the domestic economy or by the local pattern of production and distribution, all of which tend to place emphasis on the need for certain lines of work. In designing and installing the equipment at this laboratory the possibilities were always kept in mind of applying it to a wide range of problems. However, specifically, provision was made for undertaking certain investigations which, as the result of Canadian experience, had impressed the designers as being of particular interest or importance.

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The basic idea in the design of this installation has been to provide the means of establishing and maintaining for short or long periods a uniform environment of temperature and humidity which, together with standardised techniques of application, may be reproduced at any time. Thus, provision is made for studies extending over many years, in which a known environment may need to be replicated after a long lapse of time. An example of this type of work is the study of the increased resistance of organisms to chemicals, a study which is inevitably committed to the long term approach.

The principal feature of the equipment is the battery of seven fumigation chambers, which is described in more detail below. Part of the installation is also illustrated in Fig. 1. These comparatively large units were adopted for several reasons which are closely tied to the status of fumigation research at the present time.

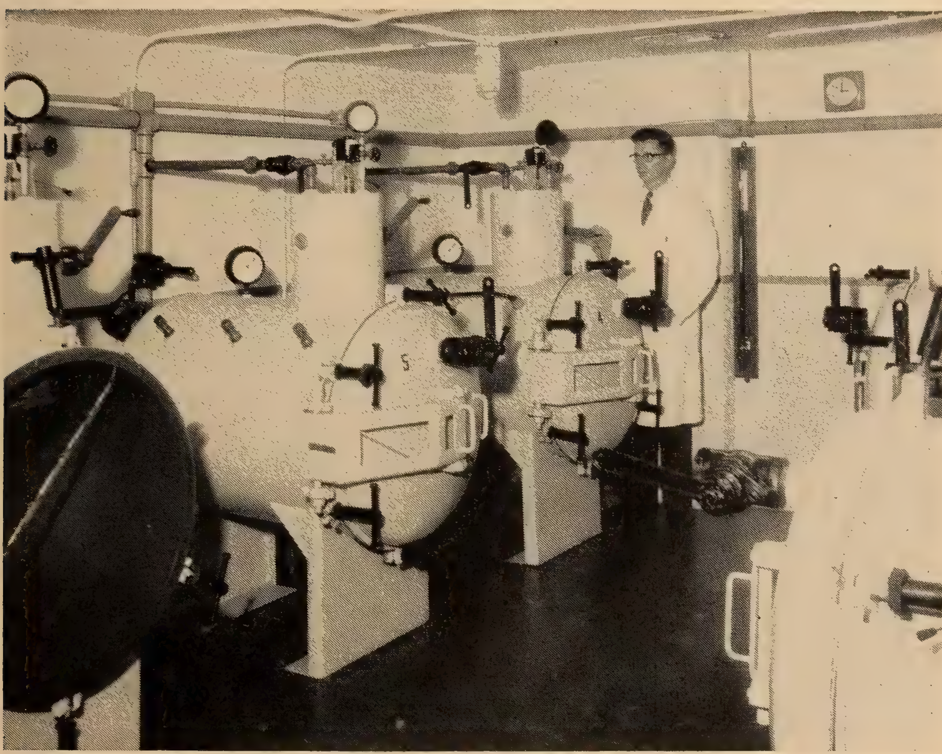

Fig. 1. Part of fumigation installation inside insulated room

Monro (4) has already pointed out the essential differences between the two types of fumigants, the so-called "space" or high pressure gases, and the low pressure vapours evolved from liquids at normal temperature. While the latter group is of great scientific interest, and holds high promise of future value to agriculture, it is with the former type that this installation is primarily concerned. The chances of discovering new space fumigants of value were also discussed by Monro in the same review. It was pointed out that, while the possibility of finding new fumigants of this type must not be ruled out, it is clear that the mathematical limitations imposed by the need for a molecule with few constituent atoms limits the number of prospects from the start. Also, a high percentage of candidate compounds are eliminated on account of undesirable characteristics such as instability, flammability, explosion hazards, corrosion of metals, tainting of foods, or destruction of plant material. Therefore, at present, the emphasis is on the better understanding of the useful and versatile space fumigants which are at present being applied in the field.

In the past, valuable research on fumigation was done by placing small batches of insects in glass containers, such as modified Erlenmeyer flasks, and exposing them to different volatile compounds or to graduated doses of the same compounds. With this type of apparatus, which is inexpensive and easy to handle in an ordinary laboratory, fruitful pioneer work was done in the early search for fumigants or in the preliminary derivation of dosage response curves for those found most promising. Today, this technique still has its place for the rapid screening of compounds against specific pests. However, it is now recognized that this method may give misleading results due to sorption of the gases, not only on the surfaces of the containers, but also on the organisms being exposed, especially if the total surface area of the organisms is large relative to the volume of the vessel. As gases differ in their rate and degree of sorption by materials the intrinsic toxicity of a fumigant released in a small vessel may be masked by the loss of concentration available for acting on the organism. These limitations have long been recognized by those working with poison gases, and have been discussed at greater length by Wachtel (7).

Because sorption may be a cause of misinterpretation in work with fumigants, it is desirable that means be available for the extraction from the system at suitable intervals of gas samples for analysis, in order that the pattern of diffusion and final degree of sorption may be observed. This can best be done with a large container, from which adequate samples can be taken without reducing significantly the total concentration of fumigant present. As a result of such sampling, it is possible to calculate the total *concentration* x *time* product of the gas actually applied to the organism during the experiment. This method applied to empty and loaded chambers is amply demonstrated by Monro *et al.* in the paper immediately following this, (5).

An important aspect of fumigation research is the relationship between the gas and the commodity. In the study of this it is desirable to work with an entire package or bag containing a given material, especially when information is needed on penetration. Thus the chambers in this installation have been made large enough to accommodate single samples of many common containers or packages.

Burns Brown (1) in a general review of fumigation research has discussed more extensively some of the above considerations influencing the design of experimental equipment in this field.

FUMIGATION ROOM

The main part of the equipment used for the fumigation experiments is housed in an insulated room. The interior is insulated with cork, six inches thick on the walls and ceilings and four inches thick on the floor. The walls are finished with plaster, the ceiling with mastic compound, and the floor with three inches of concrete. The door to the room is insulated and is of the heavy wooden type commonly used in cold storages.

If necessary, the room can be ventilated through the ceiling to the outdoors by means of a trap door which leads to a duct and powerful exhaust fan on the roof. In emergency, the trap can be sprung without entering the room. Also, the trap can be left open and ventilation continued day and night by means of an interval timer control. In practice, in order not to interfere with temperature and humidity control, the ventilating system is only operated when aeration of the chambers and their contents is in progress at the conclusion of fumigation treatments.

Temperature Control

It is desirable to be in a position to conduct fumigation research over the range of temperatures encountered in practice. In Canada, successful outdoor fumigations have been done at 20°F. (−7°C.).

In this installation there is no temperature control other than that in the main room itself. This means that experiments carried on a given day have to be done at the same temperature throughout. The temperature can be held at any required point between −7°C.

(20°F.) and 35°C. (95°F.) with a maximum variation of + or – 1°C. Obviously, workers could only remain in the room at the lower ranges for short periods of time, and experiments at such temperatures would only be done under exceptional circumstances.

Transfer of heat through the steel walls of the fumigation chambers is rapid and the temperature established in the main room is soon transmitted to the inside of them. However, experience has shown that operation of the fans within the chambers hastens the attainment of equilibrium. Temperature control is also maintained satisfactorily when the chambers are evacuated to the lowest possible pressure of approximately 8 mm. Hg. attainable with the vacuum pump employed. This is in confirmation of the theory that the thermal conductivity of any gas or mixture of gases is independent of the pressure until very low pressures are reached (3). Dickins (2) has shown experimentally that by reducing the pressure of air from normal atmospheric to 11 mm. Hg. the thermal conductivity is only slightly reduced.

Temperature stabilisation in the room is effected by means of a controller of the pneumatic electric type. The air of the room is circulated continuously through a fan cabinet containing two heating elements, the cooling coil, and two dampers. The first, or "by-pass," damper allows the air to flow through a duct in the cabinet so that it does not pass over the heating elements and cooling coil. The second is called a "face" damper, and this controls the flow of the air through the main part of the cabinet when heating or cooling is done. As needed, the controller actuates the heating and cooling systems and governs the flow of the air over these by means of the dampers. When temperature fall or rise is called for, the by-pass damper is closed and the face damper is opened for the passage of the air over the heating or cooling system, whichever is required. As the desired temperature is approached the by-pass damper gradually opens while the face damper is being progressively closed. The controller is recording and is capable of direct setting, so that any temperature within the operating range of the system may be selected as desired.

Humidity Control

Humidity in the room is maintained at a desired level by means of a hygrostat containing a hair element. The hygrostat operates an electric relay which actuates a solenoid valve on a compressed air line. When the hygrostat senses the need for moisture in the room the valve releases compressd air which aspirates water from a reservoir through a fine spray nozzle. The circulation of air by the temperature control system brings about even distribution of humidity.

The humidity control system works efficiently between temperatures of 20° and 30°C. to provide humidities between 50 and 100 per cent R.H. The lower limit is imposed by the air-conditioning of the whole building. This system also permits the maintenance of close humidity control within the fumigation chambers during experiments at atmospheric pressures in which only insects or organisms are used whose total volume is small compared to that of the chamber. The doors of the chambers are left open before the fumigations begin, and the humidity is equalised throughout. After the doors are closed the same relative humidity will persist inside the chambers for at least 24 hours, and probably considerably longer, if no temperature changes are effected.

This stabilisation of humidities has been found to be contributory to the satisfactory maintenance of uniform results in long term projects such as that reported by Monro and Upitis (6) for the selection of resistant strains of insects and their comparison with standard laboratory cultures.

FUMIGATION CHAMBERS

General description

Of the seven steel fumigation chambers in the room, six are of the general type illustrated in Fig. 2, while the seventh is a larger unit for accommodating nursery stock or trees, or for use as a gas reservoir in certain experiments. Cubic capacities are 900 litres (31.8 cu. ft) for

the large chamber and 525 litres (18.54 cu. ft.) for the six smaller ones. The steel walls and doors of the individual chambers are made of 3/16 inch steel. Owing to the importance of the problem of sorption of fumigants by the walls of the containers used for experiments, the question of a suitable paint or finish for the interior surfaces has received careful attention. The paint at present employed is one coat of red primer applied in a bakelite vehicle. This is covered with two coats of clear varnish in a bakelite resin. This varnish imparts a very smooth, shiny finish to the interior. As will be seen from the paper following this (5), this surface sorbs methyl bromide very slowly, there being a loss of only 2.5 per cent of the concentration of 24 mg. per litre of this gas in the bare chamber after 20 hours at 20°C.

The pump used for aerating the chambers is a two stage air cooled vacuum pump driven by a 5 h.p. electric motor. It has a capacity of 49.5 cubic feet per minute at atmospheric pressure and, as stated above, the lowest pressure attainable in the system of chambers is approximately 8 mm. Hg. The pump is connected with an exhaust pipe leading to the roof of the building.

The system of pipes connecting the chambers with the pump is so arranged that recirculation of the fumigant-air mixture in two of the chambers can be effected if required.

The door of each chamber is provided with a gasket of soft rubber 3/16 inch thick and 1.5 inches wide. The inside of the door has a flanged rim protruding into the chamber when it is closed. Thus only a very narrow area of the rubber surface is exposed to the fumigant and sorption of gas by this gasket is kept to a minimum. Only one of the chambers is equipped with the glass observation ports illustrated in Fig. 2. Individual features of the chambers which are of particular interest are discussed below.

Dispenser

The dispenser, so called, is a cylindrical steel vessel mounted on the main chamber and with walls of the same thickness. It has a cubic capacity of 32.5 liters (1.14 cubic feet). It may be closed off from the main chamber by means of a steel "dropping plate", which can be moved up and down and closed by an outside handle operating an internal spring, as illustrated in Fig. 2. The inside face of the dropping plate is fitted with a narrow rubber gasket which fits snugly into the base of the dispenser. The glass evaporating dish has a small 100 watt heater element underneath for evaporating liquids. This heater has the elements embedded in asbestos compound so that no hot wire is exposed. When the evaporating dish is used it is set so that it is level when the dropping plate is down. The dispenser is provided with two introduction tubes, the vapour tube for gases, and the suction tube for drawing liquids into the evaporating dish. The dispenser is also equipped with a vacuum gauge and a circulating fan, which latter is described in more detail below.

Any degree of vacuum desired down to 8 mm. Hg. pressure may be drawn on the dispenser without disturbing the pressure in the main chamber. After gases or mixtures of gases are introduced atmospheric pressure is restored in the dispenser from outside, the dropping plate is released, and the fumigants diffuse into the main chamber, aided by the action of the small fan.

This dispensing mechanism is designed for several types of manipulation:—

(1) for the complete evaporation of known weights of liquids before the vapours are brought into contact with test organisms or commodities. Thus the beginning of a fumigation is more accurately set as from the time the full nominal concentration is introduced into the main chamber.

(2) The volume of a gas or gases introduced into the dispenser may be accurately measured by means of a gauge or manometer.

(3) Mixtures of fumigants, gases or liquids, may be homogenized before they start to act on the test material.

(4) The dispenser may be closed and evacuated at any time after the beginning of the experiment without disturbing the test system. Another gas, or even a sequence of gases, may then be introduced. Thus phenomena such as that referred to as protective stupefaction may be conveniently studied.

(5) By manipulation of the dispenser the concentration of a gas in the main chamber may be progressively increased or decreased without altering the pressure or other conditions in the test system.

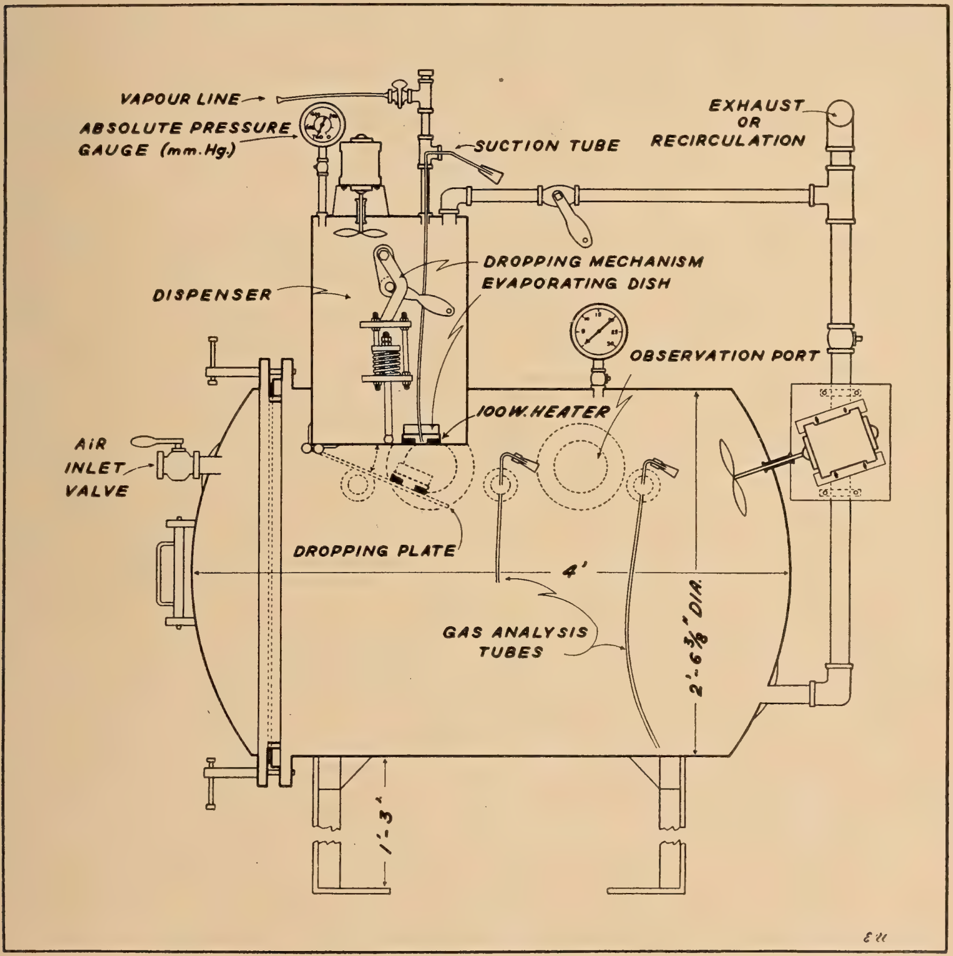

Fig. 2. Diagram of chamber for fumigation experiments.

Gas sampling

There are six threaded one inch pipe inlets in the walls of the main chambers. Copper tubes running through pipe plugs threaded in the inlets may be used for withdrawing samples of the fumigant-air mixture from different parts of a fumigation system as desired.

Insect withdrawal equipment

The chambers may be equipped for studying the effect of accurately determined fumigant concentrations on given insects or insect stages over different periods of time. These data are used for plotting curves illustrating the effect of concentration and time on insect mortality. Narrow troughs may be inserted through the threaded inlets described above so that individual

insect cages in a train can be withdrawn or inserted at predetermined intervals of time. The cages have tight fitting flanges at either end which prevent significant loss of fumigant as each cage is moved in or out. A train of these cages may be seen in the open chamber at the left of Fig. 1.

Fans

In order to avoid a heating effect and to reduce the possibility of explosion of some chemicals undergoing test, the motors driving the fans are mounted on the outside of the chambers and the shafts are led through proprietary vacuum seal units. It should be pointed out that these seal units are not specifically designed for the high speeds at which the motors operate the fans. However, they have been found to operate successfully as described below, with minor alterations in construction and restriction on operating time.

The small fan in the dispenser is 3 inches in diameter and is operated by a 1/70 h.p. shaded pole electric motor at 1550 r.p.m. The fan shaft is 1/8 inch diameter and is inserted through a high vacuum seal unit incorporating two "O" rings.

The large fan in the main chamber is 8 inches in diameter and is rotated by a 1/20 h.p. split-phase electric motor at 1725 r.p.m. The fan shaft is 3/8 inch diameter and is led through a high vacuum seal unit containing two neoprene seals. The outer seal, which is provided to withstand positive pressures, was found to be unnecessary because all the work within the chamber is done at atmospheric pressure or below. Removal of this seal reduced appreciably the frictional heating of the unit.

With both types of seal it was found that, due to the high operating speed, the manufacturers lubricant melted too readily and did not give satisfactory service. A proprietary high temperature roller bearing grease has been substituted, giving improved performance.

ACKNOWLEDGMENTS

The insulated room, the temperature control system, and some features of the fumigation chambers were designed by Mr. G. E. Humphries of M. M. Dillon and Co., Consulting Engineers, London, Ontario. During installation valuable advice in all aspects of the work was given by Mr. R. C. Hewson, Chief Engineer, London Science Service Laboratory.

The contribution of these persons is gratefully acknowledged.

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METHYL BROMIDE CONCENTRATIONS IN SHIP AND RAILWAY CAR FUMIGATION OF PEANUTS[1]

H. A. U. Monro[2], C. T. Buckland[2] and J. E. King[3]

INTRODUCTION

The use of carriers such as lake ships and railway freight cars for the large scale fumigation of plant products infested with insects has been widely adopted in Canada. The early development of this work was described by Monro and Delisle (7) and Monro (3). As a result of ten years' experience in dealing in this way with big populations of insects entering the country in foreign cargoes, it is clear that a programme of control based on treatment in the carriers has proved to be both practical and economical.

Since 1944 fumigations of this type have become standard practice throughout Canada. As long as the ships or railway cars have conformed to the types officially recognised by the Division of Plant Protection, and the technique has been carried out as recommended, the results have been uniformly successful. This success has been judged entirely on the control of the insect populations. There has been no knowledge of the distribution of the gas concentrations in the load and in the free space during the fumigation and aeration periods. Nor has there been any exact information on the extent of leakage of the fumigant from these structures.

Hayward (2) in Nigeria has studied the concentrations of methyl bromide in different positions in pyramidal and rectangular dumps of decorticated groundnuts (shelled peanuts) during fumigation under gas-proof sheets. He concluded that an important proportion of the fumigant was lost in the very porous plinths made of ground nut husks and/or cinders which formed the bases of these structures. Somade (9) has recently investigated the sorption of methyl bromide by peanuts in the shell and also after separation into husk, cotyledon, and germ. He found that the amount of the fumigant sorbed by the nuts was proportional to the moisture content. An important observation was that at increasing moisture contents above 5 per cent, germination of the seed might be progessively impaired.

The development by Phillips and Bulger (8) of the thermal conductivity gas analyser for methyl bromide has greatly helped in studies of concentrations of this gas during fumigations in the field. The application of this analyser to determinations of methyl bromide concentrations during the fumigation of empty ships has been described by Monro *et al.* (6).

At the end of May 1955 a large shipment of shelled peanuts arrived in Montreal from India. This was found to be heavily infested with insects, principally *Tribolium castaneum* (Hbst.), *Tribolium confusum* Duv., *Tenebroides mauritanicus* (L.), *Oryzaephilus surinamensis* (L.), and *Plodia interpunctella* (Hbn.).

Fumigation with methyl bromide was stipulated for most of the consignment. The peanuts were moved to destination in a number of railway cars and also in two shiploads on lake freighters.

This paper reports a study of the fumigant concentrations during the treatment on a ship in the harbour of Montreal, and in one railway car on arrival at London, Ontario.

Following the completion of the field study a number of fumigations were conducted under laboratory conditions at London. This work provided a picture of the role of sorption during the fumigation of peanuts with methyl bromide.

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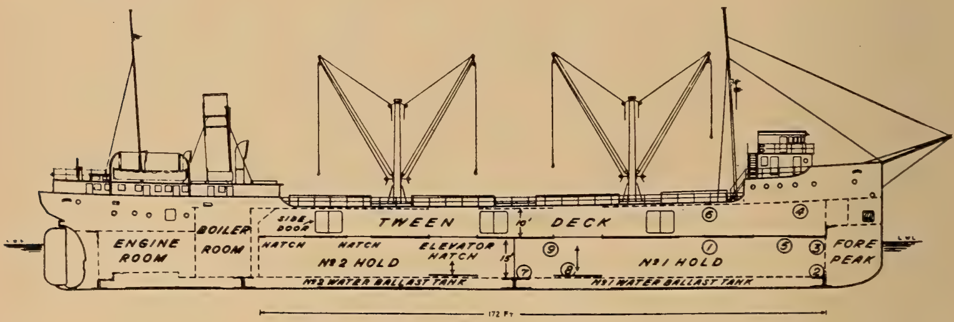
LABORATORY FUMIGATIONS

Determination of Fumigant Concentrations

The fumigation equipment used in the laboratory study has been described in the paper immediately preceding this (5). A number of non-fumigated bags of Indian peanuts from the main consignment were obtained and subjected to methyl bromide fumigation in the steel experimental chambers. Before and during fumigation these bags were pre-conditioned



Longitudinal plan of package freighter SS. "Battleford".

Fig. 1. Diagram of lake freighter used in fumigation of 1655 tons of shelled peanuts. The circled numerals show the position of the sampling points for the fumigant concentrations. The points are described in the text.

as closely as possible at the temperature and humidity prevailing during the field treatments. The dosages of fumigant corresponded also. In order to study the effect of sorption by different amounts of the commodity, separate fumigations were made at the same dosage of methyl bromide in an empty chamber, or with a load of two or three bags: to determine sorption by the jute itself a test was also made with three empty bags.

The thermal conductivity analyser was connected to the copper sampling tubes on the outside of the chambers by means of 3 feet of polythylene tubing with 3/16 inch internal diameter. One copper tube led to the free space sampling point above the load, and two or three others to the centre of the bags of peanuts, according to the number present. After passing through the analyser, the gas-air mixture was in all instances returned to the free air space in the chamber through a separate tube, not used for sampling.

In the fumigation corresponding to the one on the lake ship, the two fans in each chamber were run for 30 minutes at the beginning, and thereafter the larger fan in the main chamber was operated for 30 minutes every two hours during the day and evening, but not from 10:00 p.m. to 8:00 a.m. In the treatment parallel to the railway car fumigation, the fan was only operated for thirty minutes at the beginning.

Space Occupied by the Commodity

The actual air displacement caused by the bags of peanuts was determined with the aid of a Wet Test Gas Meter of standard type. The fumigation chamber of known volume was evacuated to a pressure of 14 mm. Hg., after which atmospheric pressure was slowly restored by directing the air through the water filled meter. The pressure differential in the meter was set at 0.5 inch of water, so that the meter revolved very slowly, transferring air at the rate of 12 cubic feet per hour. The accuracy of the meter was checked against the known volume of the empty chamber.

Determinations were then made of the volume displacement caused by one, two, or three bags of peanuts. Corrections were made for temperature and pressure and the data is presented in Table I under the heading "Space occupied (Percentage of air displaced)".

FUMIGATION IN A GREAT LAKES FREIGHTER

By coincidence, the S/S Battleford was the lake freighter assigned to move a large part of the consignment to an inland port via the Great Lakes. This was the ship used in the original study in 1947. The construction and capacity of this vessel, and the method of loading it with cargoes of peanuts in bags, was fully described in the previous report (3).

With this shipment the total space of 177,410 cubic feet was used to hold a cargo of 1655 tons of peanuts, in 11,150 bags of 112 pounds and 11,150 bags of 185 pounds. As there was a shortage of pallet boards, special loading measures were undertaken to ensure adequate free space for the diffusion of the fumigant. The load of bags was broken into three main longitudinal piles, separated by alleys two feet wide. At each hatch the piles were also crossed by one foot alleys the full width of the ship. One foot of space was provided on the entire periphery of the load between the bags and the ship's sides or bulkheads. Three feet of clearance was allowed between the top of the piles and the deck above.

The fumigation was conducted in Montreal by a commercial pest control company working under the supervision of inspectors of the Plant Protection Division.

Application of the Fumigant

The hatch covers were sealed on the outside with sheets of polyethylene (fumigation tarpaulins) which in turn were covered with the ordinary canvas tarpaulins belonging to the ship. A dosage of methyl bromide, equivalent to 34 ounces avoirdupois per 1000 cubic feet of space, was applied from cylinders through a network of copper tubing with outlets distributed evenly throughout the load. Coincident with the introduction of the fumigant four 12-inch electric fans, two in each end of the two lower holds, were turned on to aid the distribution of the gas. The fans were run for 30 minutes at the beginning and thereafter for 30 minutes at two hour intervals throughout the rest of the exposure period. The fumigation lasted 24 hours, at the end of which time aeration was started by removing tarpaulins, opening the hatch covers and side doors, and running the fans. During the fumigation, the temperature in the free space ranged from 58 to 82 degrees F. and remained fairly uniform in the commodity at 70 to 72 degrees F.

Aeration was continued for a further 12 hours, and then the ship was declared to be sufficiently clear of gas for the voyage to the inland port to begin, with some of the hatch covers and doors still open.

Post-fumigation inspection of the cargo showed that a complete control was obtained of all the insect species mentioned above as infesting the peanuts.

Gas Analysis

Gas samples were obtained by means of lengths of polyethylene tubing, some as long as 100 feet. The ends were placed, with the exception of that for the free space, inside the bags of peanuts at different positions in the 'tween decks above No. 1 hold and in No. 1 hold (forward). The sampling stations, also indicated in Fig. 1 with the corresponding numbers, were as follows:—

1. Lower hold, at top of pile, near Hatchway No. 2
2. Lower hold, near bottom at forward bulkhead, starboard side.
3. Lower hold, at top of pile, near forward bulkhead at port side.
4. 'Tween deck, near top of centre of pile, six bags back from forward bulkhead.
5. Lower hold, near centre of No. 1 Hatchway.
6. 'Tween deck, near centre, forward of No. 2 Hatchway.
7. Lower hold near deck in centre of after bulkhead.
8. Free space near deck directly opposite elevator shaft. (Only sample taken in free space.)
9. Lower hold, near centre aft of elevator shaft.

The sampling lines led to one of the two thermal conductivity gas analysers which were placed in a sheltered position on the forecastle. Periodically the two analysers, each of which had previously been calibrated against a known concentration of methyl bromide, were checked against each other.

FUMIGATION IN A STEEL FREIGHT CAR

The car used in this study, CP 258264, had the standard modern type of steel construction as described by Monro and Delisle (7).

On the inside it was 40 feet 6 inches long, 9 feet 2 inches wide, and 10 feet 6 inches high, with a cubic capacity of 3900 cubic feet. It belonged to a series officially approved for fumigation purposes by the Plant Protection Division, Canada Department of Agriculture. It was used to carry 507 of the 112-pound bags of the consignment, with a weight of 56,750 pounds, from Montreal to London, Ontario, where the fumigation was done on a siding at the premises of the importer. During the haul of nearly 500 miles from Montreal to London the bags had settled down and at the time of treatment the top of the load was only three feet above the floor, and was thus about seven feet from the ceiling. Hence there was a large air space above the load.

Application of the fumigant

The dose of 24 ounces of methyl bromide per 1000 cubic feet, with an exposure period of 16 to 24 hours, is that at present recommended for this work in approved Canadian railway freight cars, when the minimum temperature in the commodity remains above 60 degrees F. throughout the treatment. In practice, a twenty hour exposure is usually employed.

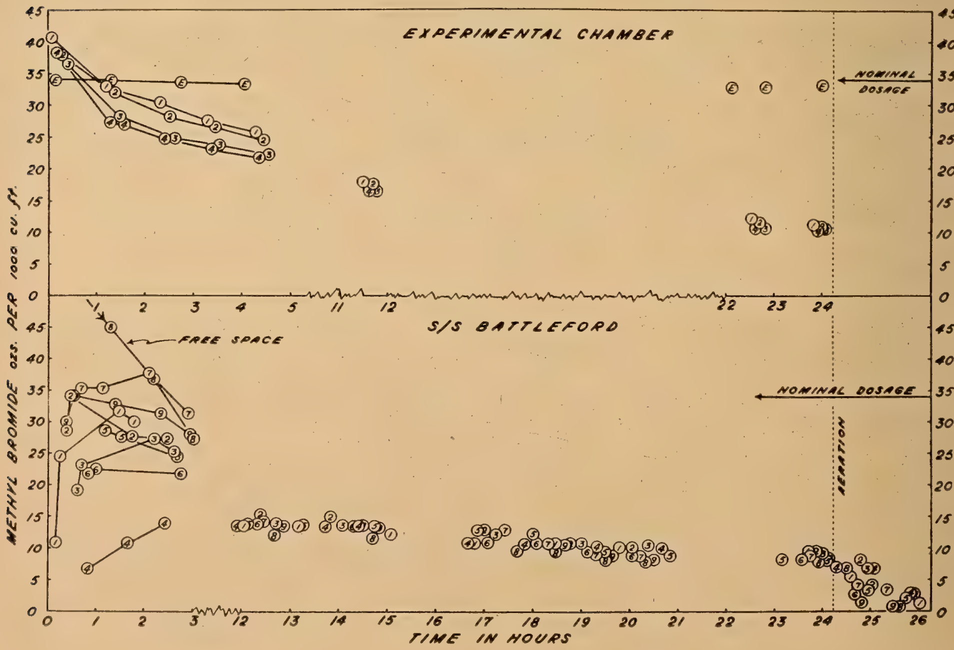


Fig. 2. Methyl bromide concentrations during fumigation of bags of shelled peanuts in laboratory experiment and on board lake freighter S/S Battleford. "E" indicates readings in empty chamber. The circled numerals refer to sampling points, which are described in the text.

The methyl bromide was discharged from six one pound cans placed on the roof of the car, in accordance with the "Can and Applicator" method (7). Polyethylene tubing connected the applicator with a copper "T" which was slightly pinched at each end and suspended inside the car four feet above the top of the load. In this way the fumigant was discharged towards each end of the car, well above the bags of peanuts. Immediately following discharge of the gas, the doors were thoroughly sealed with brown paper and flour paste in the usual manner. The fumigation lasted overnight for a total period of 20 hours. Temperature ranges were as follows: in the free air space 47 to 96 degrees F.; in the commodity 67 to 69 degrees F. The wide range in the free air is ascribed to low temperatures during the night and the effect of direct sunlight during the day.

During the early evening a Halide Leak Detector revealed small but persistent leakages at a few points in the paper sealing of the door; also, at some of the ends of the seams which join the roof plates, slight leakage was observed where the caulking compound had worn away.

Inspection at the completion of fumigation showed that a complete mortality had been obtained of the natural population of *T. castaneum* and *T. confusum,* the only species found in this particular carload.

Gas Analysis

Six polyethylene sampling tubes were led from the sampling stations through small holes drilled in the floor of the car and carried to the gas analyser housed in a wooden shed alongside the tracks.

The sampling stations were as follows:—

1. Inside bag near west end of car.
2. Inside bag near east end of car.
3. In free space near top of door.
4. In free space between the doors one foot above load.
5. Inside bag in middle of load between doors.
6. Inside bag on floor near door.

The above sampling points are indicated by the corresponding numbers in Fig. 3.

RESULTS AND DISCUSSION

The results of the determination of methyl bromide concentrations during the fumigations in the ship, the railway car, and the empty and loaded laboratory chambers are set out in Figs. 2 and 3. For the laboratory chambers, in both graphs, the readings labelled (E) are those for the empty chamber, (1) for the free space above the load and (2) or (3) for sampling points within the bags. For the ship and the railway car the numbers in the graph correspond to those already listed in the text.

The pertinent data obtained both in the field and the laboratory is summarised in Table I, which demonstrates the loss by sorption of the fumigant and the effect of this on the *concentration* x *time* products.

Laboratory Fumigations

From the results described below and also from careful checking of all possible points of leakage from the chambers it may be assumed that loss of fumigant to the outside air was negligible.

The lines for samples taken in the empty chambers in the two experiments demonstrated in Figs. 2 and 3 show that a very small proportion of methyl bromide was sorbed. These chambers thus provide a very useful tool for investigating the sorption of methyl bromide, and possibly other fumigants, by containers such as bags and boxes holding all types of commodities.

Sorption of the fumigant by the commodity and the jute bags containing it is considerable. That the peanuts themselves, and not the jute bags, are mainly responsible for the retention of fumigant is demonstrated by the results of a separate test on three empty bags, shown in Table I.

The thermal conductivity gas anlyser used in this work withdraws the gas air mixture at the rate of one cubic foot per hour, which is approximately equal to 0.5 litres per minute. In order to make an accurate reading at any point it was usually necessary in the laboratory tests to run a given sample for two minutes. Thus for analysis at a given point one litre of the fumigation atmosphere passed through the machine. In a small chamber of the size used in the laboratory there is obviously only an approximation in the determination at any one point unless equilibrium has been attained throughout the system.

In the present study the gas analyser was used in the laboratory because a direct comparison was being made with the results from the use of the instrument in the field.

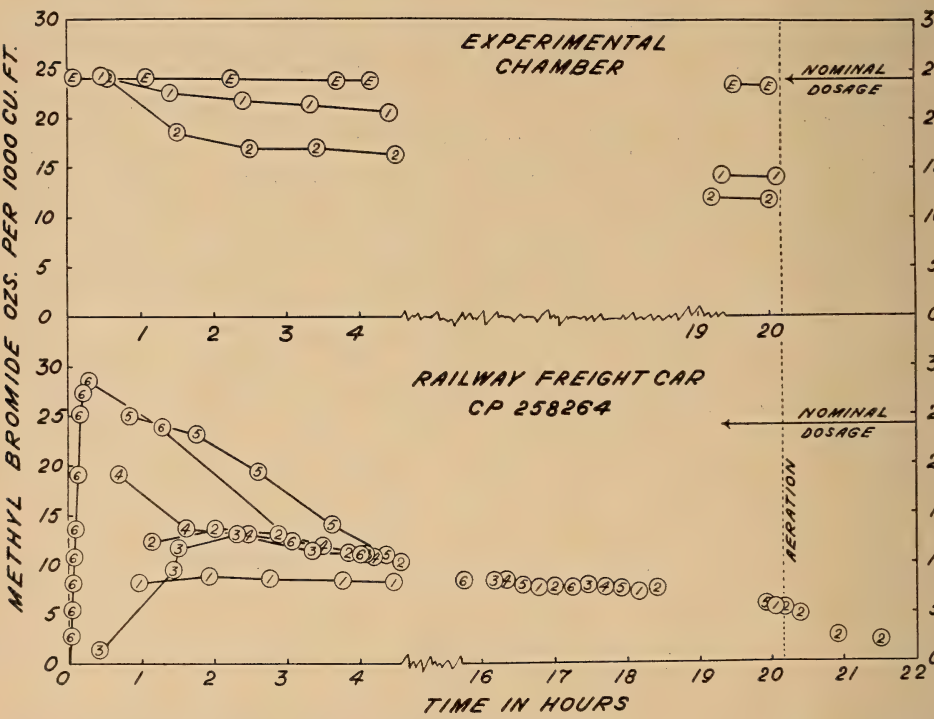


Fig. 3. Methyl bromide concentrations during fumigation of bags of shelled peanuts in laboratory chamber and in railway freight car. "E" indicates readings in empty chamber. The circled numerals refer to sampling points, which are described in the text.

Ship Fumigation

The results of the fumigant anlysis made during the treatment on board the ship are compared in Fig. 2 with a fumigation in the laboratory of approximately the same weight of material per volume of space. Temperature conditions in the commodity were identical in both treatments.

The use of circulating fans throughout the cargo space of the ships led fairly rapidly to the attainment of a state of equilibrium throughout the system. The continued slight fall in concenration up to the end of the treatment is in agreement with observations made in the laboratory chamber. This may be attributed, therefore, to the effect of sorption of the fumigant by the load, which is a continuous process for the times observed in this study.

As will be seen from Table I, at the end of the fumigations the percentage loss of the original nominal dosage of the fumigant in the air was 67 per cent for the laboratory chamber, and 77.8 per cent for the cargo space in the ship.

Thus it may be concluded that, in this ship fumigation, sorption of the fumigant by the commodity was the principal cause of the fall of concentration and that other factors, such as sorption by the structure and leakage of the gas into the open air, played only a small part.

Railway Car Fumigation

In Fig. 3 the results of the analysis in the railway car are compared directly with a parellel treatment in the laboratory. The conditions in the car were different from those in the ship, as the load had settled to the lower part of the car and the fumigant was discharged into an open space above it. Hence, although fan circulation was not employed, the concentrations merged quite rapidly into equilibrium in all parts of the system.

In terms of a weight/space ratio, the weight of peanuts in two or three bags fumigated in the laboratory did not correspond to that found in the car. The data in Fig. 3 for methyl bromide concentrations in the chamber are based on a load of two bags. As will be seen from Table I, the load in the chamber corresponding to the contents of the car lay between two and three bags. Therefore the data has been interpolated in this table to give a sorption factor (percentage loss of nominal dosage) for a load equivalent to that in the car.

From Table I it is seen that, at the end of the 20 hour treatment, the percentage loss of the nominal dosage in the air of the car was 75.8 compared with the estimate of 48.8 for the experimental chamber. The difference is appreciably greater than for the lake ship. Railway cars of this type have wooden floors and walls, which in themselves would account for some sorption. Although leakage doubtless plays some part in fumigant loss, this is not important. Sorption of the fumigant by the commodity itself is still the principal source of loss of the initial concentration.

It may be concluded from this trial that the standard steel railway freight car holds the vapours of methyl bromide at comparatively high concentrations throughout a twenty hour exposure period.

Concentration x time products and insect mortality

As stated, fumigations with methyl bromide of imported plant products in lake ships, railway cars, and other carriers have, under normal conditions, been completely successful in destroying insect infestations. All failures have been explained by faulty methods of application or by the fact that the treatments were done in leaky structures not recommended by the Division of Plant Protection for this type of work. The results obtained in the present study, expressed in terms of *concentration* x *time* products, will indicate why this is so.

Estimates obtained in the laboratory of minimum effective treatments to control insects are usually based on certain criteria, such as the doses producing 95, 99, or 99.9 per cent mortality. These estimates are actually readings from regression lines projected on the laboratory data when the doses have been plotted against mortality in terms of logarithms of the values or transformed to specially devised statistical units such as probits. As the mortality curve is asymptotic to the 100 per cent value, a valid statistical estimate of the latter is impossible, whereas mortalities of 99 and 99.9 per cent can justifiably be read from the regression lines, although the limits of confidence at these points are far wider than at the 50 per cent point. It has been usual for authors to choose 99 or 99.9 per cent mortality readings from their regression lines as being an indication of the treatment which might be expected, in practice, to yield complete mortality of the insects in question.

Burns Brown (1) has published in tabular form an estimate of minimum *c* x *t* products of methyl bromide required to kill the more resistant stages of nine important stored product insects at temperatures ranging from 50 to 77 degreee F. His data is a summary of a large body of still unpublished information accumulated at the Pest Infestation Laboratory, De-

TABLE I

The relationship between loads of commodity and *concentration* x *time* products of fumigant in the treatment of peanuts with methyl bromide

Structure	Number of bags and total weight	Space occupied (percentage of air displaced)	Ratio weight/space in lbs. per cu. ft.	Temperature of commodity degrees F.	Relative humidity fumigation space	Nominal dosage ozs. per 1000 cu. ft.	Exposure period in hours	Percentage loss of nominal dosage in free space	Conc. x time products ozs. per 1000 cu. ft. hours: In free space	Conc. x time products ozs. per 1000 cu. ft. hours: Minimum in commodity
Experimental chamber (18.5 cut. ft.)	Nil	chamber empty	—	72° (in chamber)	—	34	24	3.2	—	—
	3 bags (336 lbs.)	25.1	18.1	72°	68-72%	34	24	67.0	506	426
S/S Battleford (177,410 cu. ft.	22,300 bags (1655 tons)	25.8 (est.)	18.6	71°	74-75%	34	24	77.8	432	285
Experimental chamber (18.5 cu. ft.	Nil	chamber empty	—	68° (in chamber)		24	20	2.5	—	—
"	3 empty bags (4 lbs. 4 ozs.)	empty jute bags	—	68°		24	20	8.2	—	—
"	2 bags (224 lbs.)	16.7	12.1	68°	65%	24	20	41.2	358	295
"	3 bags (336 lbs.)	25.1	18.1	68°	65%	24	20	60.0	303	240
"	**270 lbs.**	**20.1** (a)	**14.6** (a)	**68°**		**24**	**20**	**48.8** (a)	**335** (a)	**273** (a)
Car CP258264 (3900 cu. ft.)	507 bags (56,750 lbs.)	20.1 (est.)	14.6	67-69°	60-70%	24	20	75.8	197	153

(a) Estimated values obtained by interpolation of data for 2 and 3 bags.

TABLE II

Estimated minimum *concentration* x *time* products for methyl bromide against various insects, expressed in milligrams per litre hours. Relative humidity 70%

INSECT SPECIES	20°C. (68°F.) PERCENTAGE MORTALITY 99	20°C. (68°F.) PERCENTAGE MORTALITY 99.9	25°C. (77°F.) PERCENTAGE MORTALITY 99	25°C. (77°F.) PERCENTAGE MORTALITY 99.9	AUTHORITY
1. *Tenebroides mauritanicus* (L.)					
(a) Fourth instar larvae	180	200	115	150	Monro and Bond (4)
(b) Adults	—	—	115	150	Monro and Bond (4)
2. *Sitophilus granarius* L.					
Adults	—	—	(i) 30	(i) 35 (ii) 40	(i) Monro and Bond (4) (ii) Burns Brown (1)
3. *Tribolium confusum* Duv.					
(a) Adults	—	—	60	(i) 70 (ii) 65	(i) Monro and Bond (4) (ii) Burns Brown (1)
(b) Pupae	—	—	—	100	Burns Brown (1)
4. *Trogoderma granarium* Everts.					
Larvae	—	—	—	100	Burns Brown (1)
5. Minimum effective *c* x *t* products for all stored product insects studied at Slough Laboratory, D.S.I.R., England.	—	150	—	100	Burns Brown (1)

partment of Scientific and Industrial Research, Slough, England. The insect cited by Brown as being most resistant to methyl bromide is the larva of the Khapra beetle, *Trogoderma granarium* Everts. At this laboratory (4) we have obtained data on the *c* x *t* products of methyl bromide to control the fourth instar larva of the cadelle T. *mauritanicus* L. This larva and its adult have approximately the same resistance to methyl bromide, which is greater than any of the species mentioned by Brown. Some pertinent figures demonstrating minimum *c* x *t* products are summarized in Table II.

It is customary for *concentration* x *time* products based on laboratory results to be expressed as milligrams per litre hours. For practical purposes milligrams per litre are the same as ounces per thousand cubic feet. Therefore laboratory work can conveniently be transposed for field purposes into the units commonly used in practice. The data in Table I is expressed in ozs. per 1000 cu. ft. hrs., and that in Table II in mg./l hrs.

For the lake freighter in the present study the minimum *c* x *t* product of 285 is well above that required to obtain complete mortality of any of the insects in the shipment. In the railway car a product of 153 would be adequate for all species present except *T. mauritanicus.* For this latter insect the figures in Table II indicate that for 20 hours exposure the *c* x *t* products are 180 and 200 for mortalities of 99 and 99.9 per cent respectively. On arrival at London no stages of *T. mauritanicus* were found in this part of the shipment. However, in the past the treatments recommended for railway cars have been uniformly successful against this insect.

The application to field conditions of minimum *c* x *t* products estimated in the laboratory raises the question as to what standards will provide the most practicable guide. Undoubtedly, the standard of 99.9 per cent mortality will allow for a very wide margin of safety, but other authors have used the minimum treatment giving 100 per cent kill, a standard which can usually be demonstrated when test populations are kept within reasonable numbers.
It is hoped that accumulation of information such as has been presented in this paper will, in the long run, serve to relate laboratory findings to practical conditions.

SUMMARY

1. The concentrations of methyl bromide during the fumigation of shelled peanuts in a lake ship and a railway freight car have been recorded.
2. The field conditions have been simulated as closely as possible in the laboratory.
3. It is concluded that sorption of the fumigant by the commodity itself is the major source of the loss of the nominal dosage from the free air.
4. The relation of the observed *concentration* x *time* products of the fumigant to the mortality of some important stored product insects is discussed.

ACKNOWLEDGMENTS

The authors wish to acknowledge the kind assistance provided by Mr. George Worth, Pestroy Limited, Montreal, P.Q., and by officials of the Gorman Eckert Company Limited, London, Ontario.

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INSECTICIDAL POTENCY AND PHYTOTOXIC EFFECT OF COMPOUNDS SCREENED DURING 1955[1]

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INTRODUCTION

During the past year energy and initiative have been directed towards accelerating all operations, towards eliminating unsatisfactory parts of rearing and handling techniques and towards minimizing health hazards. In manipulative procedures time has been gained, firstly by simultaneously spraying the two species of aphids in each test sample and secondly, by combining direct spray and residual effect applications in the same session of operations. Health hazard has been minimized by wearing a gas mask and surgeon's cap and gown as protective clothing. The spray room is equipped with an exhaust duct and fan.

In the period under review, *all* compounds have been tested for residual effect, using the aphids, *Aphis fabae* Scop and *Macrosiphum pisi* (Harris)[2] as well as for direct spray effect by our standard bioassay (8, 9). In the same general experimental design (9) assessments have been made of the phytotoxicity of the compounds to the broad bean, *Vicia faba* L. The tests have, as heretofore (8), included assessments of aphid population susceptibility (using lindane: 99% gamma isomer benzene hexachloride), population natural mortality and carrier toxicity.

The percentage of lindane in the lindane checks has mostly been 0.05%. As this caused almost complete mortality and thus made bioassay comparisons difficult it was decided to decrease the concentration. This was done progressively to 0.0165% weight/volume. Even at this low concentration lindane was highly toxic in residual effect tests (10).

Most of the compounds have also been tested against two species of Coleoptera: *Sitophilus granarius* (L.) and *Tribolium* sp. using appropriate lindane emulsion and natural mortality checks.

A few compounds which have seemed of particular interest have been tested for systemic and fumigant effect.

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[1]No. 3 in a series of papers.

[2]Although Palmer (11) gives (Kalt) as authority for this name, it is given as (Harris) in "Common Names of Insects Approved by the Entomological Society of America" in Bull. ent. Soc. Amer. Dec. 1955.

REARING AND HANDLING INSECTS

Aphids—See Musgrave and Kukovica (8).

Beetles—Species of *Sitophilus* have been reared on whole wheat grains in small vials in glass humidors. *Tribolium* sp. have been reared on a compressed rabbit food or, alternatively, on a mixture of corn meal and yeast (12).

The beetles have been handled mostly by finger tips or small brushes, which seemed to cause less injury than forceps.

CHEMISTRY OF COMPOUNDS

The chemistry of compounds tested has been described elsewhere (1, 3, 4, 5, 7). Most of them were prepared by Dr. M. Kulka and Dr. F. Stryk of the Dominion Rubber Co. Research Laboratories, Guelph, Ontario.

FORMULATIONS

Most of the compounds were tested in a benzene emulsion at the 1% level, as previously: 1 gm. of compound in 5 ml. benzene, emulsified with water to make 100 ml. The emulsifier used chiefly was Emulfor EL. Some compounds were emulsified with Emulfor ON or Triton X 100. These are noted in Table II. Emulfor EL is a product of castor oil and polyethylene oxide. Emulfor ON is a product of oleyl alcohol and polyethylene oxide. Triton X 100 is an alkyl aryl polyether alcohol.

As a check on the effect of the emulsions on the toxicity of the compounds some replicated tests using our lindane sample made up with three different emulsifiers were run. The results are given in Table I. It can be seen that the emulsifying agents do not greatly affect the basic toxicity of lindane. The changes that it was necessary to make in emulsifying agents can therefore be assumed not to affect our assessment of compounds.

Incidentally, the results also show that *A. fabae* is more resistant to lindane than *M. pisi*. Further evidence of this is presented elsewhere (10).

A few compounds had to be formulated in acetone or alcohol solutions of varying concentrations. Some were tested in water solutions.

TREATMENTS

Direct Spray and Residual Effect

Aphids—As previously described (8).

Beetles—These have been tested by direct spray by placing them on treated filter papers, spraying them in the Potter tower and then tipping them into petri dishes containing clean filter paper. For residual effect they have been tested by the well-known method of constraining them to walk over treated filter paper. Each population sample of test insects was constrained to walk on the appropriate filter paper by being confined on it by means of a glass cylinder 2½" in diameter and ½" high: the insects walked around in a glass-sided arena.

Systemic action

Three methods have been used to test for any systemic action of the compounds:

i) Seed treatment
ii) Root application
iii) Painting of leaves

i) *Seed Treatments.* Bean seeds were soaked in the emulsion or solution of the compound for 4 to 6 hours and then allowed to dry. They were planted next day in small pots with soil and encouraged to germinate. When the plants were three inches high, aphids were introduced and the plants set up in a post-treatment cage. This method appears to be similar to that used by David and Gardiner (2).

ii) *Root applications.* The plants were "watered" with the insecticidal solutions or emulsions. Aphids were later placed on them. The soil and pot being appropriately protected.

iii) *Painted leaves.* Some leaves of the plant were painted with the compound with a camel hair brush. Four hours later the painted leaves were cut off very carefully to prevent them contaminating other leaves, and aphids were introduced on the plants.

RESULTS

The number of compounds screened during the year was 274. A complete list is given in Table II on page .

Compounds toxic to Coleoptera

In the formulations used, only lindane (benzene-hexachloride) and diazinone *O*, 2-isopropyl-4-methylpyrimidyl-*o,o* dimethyl phosphorothioate) were significantly toxic to the granary weevil, *S. granarius,* and the flour beetle, *Tribolium sp.*

Compounds markedly aphicidal

p-Chlorobenzyl 2-thiocyanoethyl sulphide
Phenylethyl 2-thiocyanoethyl sulphide
p-Chlorophenyl 4-thiocyanobutyl sulphide
Thiocyanoethylphenyl sulphide
p.p'-Chlorobisphenylmercapto-propane
Diazinone (*O*, 2-isophopyl-4-methylpyrimidyl *O,O*-dimethyl phosphorothioate).

Phytotoxic Compounds

p-Xylylene dimercaptan
2,4-Dichlorophenyl 2-chloroethyl ether
p-Nitrophenyl 2-chloroethyl ether
Amyl 1,2-dichlorovinyl sulphone
3,4-Dichlorobenzyl 2-thiocyanoethyl ether
t-Butyl-chloromercurifuran
Thiocyanoethylphenyl sulphide

Systemic Effect

None of the compounds tested for systemic effect showed any evidence of it.

Unexpected Response

The compound p-chlorobenzyl 1,2-dichlorovinyl sulphide (Sample No. 624) was interesting in that it was found to be only slightly toxic as a direct spray but distinctly toxic as a residual deposit. No satisfactory explanation is at present available. The following compounds had a similar response:

2,4-Dichlorophenyl 2-chloroethyl ether
Ethoxythiophosphono-bis-ethyl-xanthate
p-Chlorophenyl 1,2-dichlorovinyl sulphide
3,4-Dichlorobenzyl 1,2-dichlorovinyl sulphide
p-Chlorophenyl mercaptobutyl chloride
p-Chlorophenyl-bromopropyl sulphide
p-Chlorobenzyl allyl sulphide
t-Butyl-chloromercurifuran
Sodium benzyldithiocarbamate

REMARKS

Once again most of the year's outstanding compounds contained the SCN radicle. Contrary to a comonly held opinion about thiocyanates, they were not all phytotoxic.

It will be seen that the phytotoxicity of some compounds was such that they seemed to render the plants upon which they were sprayed, unfit for the aphids and death ensued from starvation. Such results have been given an assessment, P, in Table II. This point is discussed elsewhere (10).

ACKNOWLEDGMENTS

It is a pleasure to acknowledge the whole-hearted cooperation of Dr. Marshall Kulka and Dr. Frederick Stryk of the Dominion Rubber Company Research Laboratories, Guelph, whose grant-in-aid has partly supported this project. We gladly extend our thanks to Dr. W. E. Heming, Head, Department of Entomology and Zoology, Ontario Agricultural College, in whose Department this work was done.

TABLE I

Shows LD_{16}, LD_{50} and LD_{84} of lindane emulsions made with the three emulsifying agents. the data must be regarded as significantly heterogeneous (6).
Figures are percent concentrations. They were obtained by analysis of results by the graphical method of Litchfield and Wilcoxon (6). If $(Chi)^2$ for these results exceeds 7.82 the data must be regarded as significantly heterogeneous.

	L.D.	Triton X100	Emulfor EL	Emulfor ON
M. pisi	L.D. 16	.006	.0078	.0062
	L.D. 50	.010	.012	.0082
	L.D. 84	.0167	.013	.013
$(Chi)^2$		**4.06**	**12.03**	**14.4**
A. fabae	L.D. 16	.009	.006	.0065
	L.D. 50	.022	.020	.015
	L.D. 84	.052	.058	.035
$(Chi)^2$		**1.09**	**1.05**	**5.35**

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TABLE II

Compounds are listed by chemical classification. The sample number is given in the left hand column as a convenient reference. The compounds were formulated as 1% and in the benzene emulsion (p. 76) unless otherwise stated.

To the right of each compound consecutively are listed:

i) its phytotoxicity (yes, no, slight);

ii) its effect as a direct spray to *M. pisi* and *A. fabae.*

iii) its residual effect against *M. pisi* and *A. fabae;*

O--indicates less than 70% mortality—assessed as non-insecticidal.

F—indicates 70% to 94% mortality—assessed as slightly insecticidal.

T—indicates 95% to 100% mortality—assessed as insecticidal or promising.

P—aphid mortality considered due to drastic effect of compound on plant.

Thus: Yes O F O T — would indicate a compound to be phytotoxic, non-toxic to *M. pisi* as a direct spray, slightly toxic to *A. fabae* as a direct spray, non-toxic to *M. pisi* as a residual insecticide and toxic to *A. fabae* as a residual insecticide.

The assessments have been made rigorous deliberately to allow for natural and check mortalities and because a compound has to be outstanding to compete with those already available.

Assessments marked with * were made from means. All others from single tests.

SULPHIDES

762	p-Chlorobenzyl allyl sulphide	Yes	O	O	F	T
798	Dibenzyl thiuram disulphide (in 70% acetone)	No	O	O	O	O
807	bis-p-Chlorobenzyl sulphide	No	F	F	O	O
816	Benzyl 3-nitro 4-methoxybenzyl sulphide	No	O	O	O	O
817	1,4-bis (p-Chlorobenzylmercapto)-2-butene	No	O	O	O	O
818	1,4-bis (p-Chlorobenzylmercapto)-2, 3-dithiocyanato-butane	No	O	O	F	T
819	1,4-bis (p-Chlorobenzylmercapto)-2, 3-dibromobutane	Slight	O	O	O	O
761	p-Chlorophenyl β-bromopropyl sulphide	Slight	O	O	F	T
771	p-Chlorobenzyl β-bromopropyl sulphide	Yes	O	O	O	O
772	p-Chlorobenzyl 4-chlorobutyl sulphide	Yes	F*	F*	O*	O*
779	p-Chlorobenzyl 3-thiocyanopropyl sulphide	Yes	O*	F*	O*	O*
780	p-Chlorobenzyl 4-thiocyanobutyl sulphide	Yes	T*	T*	F*	T*
786	Phenyl 2-chloroethyl sulphide	Yes	O	O	O	O
787	Phenyl 2-thiocyanoethyl sulphide	Yes	T*	F*	T*	T*
793	2-Dihydroxyethyl sulphide	Slight	O	O	O	O
756	p-Chlorophenyl 4-chlorobutyl sulphide	Yes	O	O	T	T
759	p-Chlorophenyl 4-thiocyanobutyl sulphide	Yes	F*	T*	O*	O*
760	p-Chlorophenyl 3-thiocyanopropyl sulphide	Yes	T	T	O	O
721	p-Chlorophenyl 1,2,2,2,-tetrachloroethyl sulphide	Slight	O	O	O	O
722	p-Chlorophenyl 2,2,2,-trichloro-1-hydroxyethyl sulphide	No	O	O	O	O
728	p-Chlorophenyl 2,2,2-trichloro-1-thiocyanoethyl sulphide	Slight	O	F	O	O
729	p-Chlorophenylethyl 1,2-dichlorovinyl sulphide	No	O	O	O	O
735	p-Chlorobenzyl chloromethyl sulphide	No	O	O	O	O
739	p-Chlorobenzyl thiocyanomethyl sulphide	No	O	O	O	O
720	p-Chlorophenyl 1,1,1-trichloro-3-nitropropyl sulphide	Yes	O	O	O	O
708	p-Chlorophenyl chloromethyl sulphide	Yes	O	O	O	O
712	p-Clorophenyl thiocyanomethyl sulphide	Slight	O	O	O	O
719	p-Clorophenyl 1,2-dichlorovinyl sulphide	Slight	O	O	F	T
674	p-Chlorophenylethyl 2-chloroethyl sulphide	Yes	O	O	O	O

675	p-Chlorophenylethyl 2-thiocyanoethyl sulphide	Yes	O	F	O	O
653	p-Chlorophenylethyl 2-chloroethyl sulphide	No	O	O	O	O
652	bis (p-Chlorophenacyl) sulphide (in 100% acetone)	No	O	O	O	O
654	p-Chlorophenyl 1-phenyl-2-bromoethyl sulphide	Yes	O	F	O	O
610	Phenylethyl 2-thiocyanoethyl sulphide (0.5%)	Slight	O	O	O	O
580	Phenylethyl 2-thiocyanoethyl sulphide (1.0%)	Yes	T	T	O	O
615	p-Chlorophenyl o-thiocyanocyclohexyl sulphide	No	O	O	O	O
630	1-Chlorobenzyl 4-bromocyclohexyl sulphide	No	O	O	O	O
632	p-Chlorobenzyl 4-thiocyanocyclohexyl sulphide	No	O	O	O	O
578	α-Naphthyl methyl 2-cyanoethyl sulphide	No	O	O	O	O
579	Phenylethyl 2-chloroethyl sulphide	Yes	O	O	T	T
605	p-Chlorophenyl 4-bromocyclohexyl sulphide	Slight	O	O	O	O
559	2,4-Dichlorobenzyl 2-chloroethyl sulphide	Yes	O	O	O	O
558	3,4-Dichlorobenzyl 2-chloroethyl sulphide	Yes	O	F	O	O
557	p,p'-Dichlorobenzhydryl 2-chloroethyl sulphide	Yes	O	O	O	O
567	2,4-Dichlorobenzyl 2-thiocyanatoethyl sulphide	Slight	F	T	O	O
568	3,4-Dichlorobenzyl 2-thiocyanatoethyl sulphide	Yes	T	F	O	O
569	Diisobutyl 2-chloroethyl sulphide	No	O	O	O	O
570	Diisobutyl 2-thiocyanatoethyl sulphide	Yes	F	O	O	F
550	p-Chlorobenzyl 2-thiocyanatoethyl sulphide	Slight	T*	T*	O*	O*
572	2,4-Dimethylbenzyl 2-thiocyanatoethyl sulphide	No	F	F	O	O
568	3,4-Dichlorobenzyl 2-thiocyanatoethyl sulphide	Yes	T	F	O	O
583	p-Xylylene bis-2-thiocyanatoethyl bisulphide	No	O	O	O	O
584	α-Naphthylmethyl 2-thiocyanatoethyl sulphide	No	F*	T*	O*	O*
582	p-Chlorobenzyl 2-hydroxy-3-chloro-propyl sulphide	Slight	O	O	O	O
590	p-Chlorobenzyl 2,3-bis-thiocyanatopropyl sulphide (0.5%)	No	O	O	O	O
588	p-Chlorobenzyl 2,3-dichloropropyl sulphide	No	O	O	O	O
589	p-Chlorobenzyl 2-hydroxypropyl sulphide	Yes	O	O	O	O
550	p-Chlorobenzyl 2-thiocyanatoethyl sulphide	Slight	T	T	O	O
602	p-Chlorobenzyl 2-chloropropyl sulphide	Yes	O	O	O	—
603	p-Chlorobenzyl 2-thiocyanatopropyl sulphide	Yes	O	O	O	O
618	4-Chloronaphthylmethyl 2-chloroethyl sulphide	No	O	O	O	O
619	4-Chloronaphthylmethyl 2-thiocyanatoethyl sulphide	Yes	F	T	O	O
622	3-Phenylpropyl 2-thiocyanatoethyl sulphide	Yes	F	O	O	O
623	3-Phenylpropyl 2-chloroethyl sulphide	Yes	O	T	F	T
624	p-Chlorobenzyl 1,2-dichlorovinyl sulphide	Slight	O*	O*	T*	T*
713	3-p-Chlorophenylpropyl 2-thiocyanatoethyl sulphide	Yes	T	F	O	O
716	3-p-Chlorophenylpropyl 2-chloroethyl sulphide	Yes	O	O	O	O
726	Amyl 1,2-dichlorovinyl sulphide	No	O	O	O	O
724	Diisobutyl 1,2-dichlorovinyl sulphide	No	O	O	O	O
727	1,4-bis-Amylmercapto-2,3,5,6-tetrachlorobenzene	No	O	O	O	O
733	2,4-Dimethylbenzyl 1,2-dichlorovinyl sulphide	No	O	O	F	T
732	3,4-Dichlorobenzyl 1,2-dichlorovinyl sulphide	No	O	O	F	F
731	p-Chlorobenzylmercaptoacetic acid	Yes	O	O	O	O
738	N-Hydroxy p-chlorobenzylmercaptoacetamide (in 70% acetone)	No	O	O	O	O
741	2,4-Dichlorobenzyl 1,2-dichlorovinyl sulphide	No	O	O	T	O
742	2-Chloroethyl p-chlorobenzylmercaptoacetate	Yes	O	O	O	O
743	Bis (p-t-butylphenoxyethyl) sulphide	No	T	O	O	O
745	Ethyl p-chlorobenzylmercaptoacetate	Yes	O	O	O	O
746	1,4-bis (p-Chlorobenzylmercapto) 2,3,5,6-tetrachlorobenzene	No	O	O	O	O
564	Diisobutyl cyanoethyl sulphide	No	O	O	O	O
565	Diisobutyl 2-cyano-2-chloroethyl sulphide	No	O	O	O	O
667	α- (2-Pyridinoethyl) p-chlorophenyl sulphide	Yes	O	O	O	O
666	α- (2-Pyridinoethyl) p-chlorobenzyl sulphide	No.	T	O	O	O
682	α- (2-Pyridinoethyl) p-chlorophenyl ethyl sulphide	Yes	O	O	O	O
681	bis-α- (2-Pyridinoethyl) sulphide	Slight	O	O	O	O
690	α- (2-Pyridinoethyl) 2-chloroethyl sulphide (in 60% acetone)	No	O	O	O	O
688	α- (2-Pyridinoethyl) 2-thiocyanatoethyl sulphide	Slight	F	O	O	O
689	α- (2-Pyridinoethyl) p-ethylphenyl sulphide	Yes	O	O	O	O
695	α- (2-Pyridinoethyl) o-isopropylphenyl sulphide	Yes	O*	O*	O*	O*
694	o-Isopropylphenyl 2-thiocyanoethyl sulphide	Yes	T*	F*	O*	O*
753	3-Chloro-2-butenyl p-Chlorobenzyl sulphide	Yes	O	O	O	O
556	p-Chlorobenzyl 2-cyanoethyl sulphide	No	O	O	O	O
562	3,4-Dichlorobenzyl 2-cyanoethyl sulphide	Slight	O	O	O	O
673	p-Chlorophenyl 1-phenyl-2-thiocyanoethyl sulphide	Slight	O	O	O	O
698	bis (p-Chlorophenylmercapto) methane	No	F	T	O	O
757	1,4-bis (p-Chlorophenylmercapto) butane	No	O	O	O	O
758	1,3-bis (p-Chlorophenylmercapto) propane	No	F	T	O	O

704	Tris-(p-Chlorophenylmercapto) methane	Slight	O	O	O	O
769	1,3-bis (p-Chlorobenzylmercapto) propane	Yes	O	O	O	O
770	1,4-bis (p-Chlorobenzylmercapto) butane	Yes	O	O	O	O
748	Diethyl disulphide	No	O	O	O	O
749	2-Chloro-1-phenylethyl vinyl sulphide	No	O	O	O	O
542	bis-p-Nitrobenzyl disulphide (in 100% acetone). Crystallised in tower	No	—	—	O	O
539	bis-2-Chloroethyl p-xylylene disulphide	No	O	O	O	O
527	p-Chloronaphthyl 2-thiocyanoethyl sulphide	No	O*	O*	O*	O*
571	2,4-Dimethylbenzyl 2-chloroethyl sulphide	Yes	O	O	O	O
521	4-Chloronaphthyl 2-chloroethyl sulphide	No	O	F	O	O
522	p-Chlorobenzyl 2-chloroethyl sulphide	Yes	O	O	O	F

FURANS

511	Acetone-furan condensation product	No	O	O	O	O
512	1,2-Dibromo-1,2-dipivolylethane	No	O	O	O	O
513	*Trans* - dipivalyl ethylene	No	O	O	O	O
594	N,N-Diphenyl isomethyl thiourea (in water)	No	O	O	O	O
595	N,N-Diphenyl isoethyl thiourea hydroiodide (in water)	No	O	O	O	O
596	4,4'-Dichloro-N,N-diphenyl isoethyl thiourea hydroiodide	No	O	O	O	O
597	4,4'-Dichloro-N,N-diphenyl isoethyl thiourea hydroiodide (in water)	No	O	O	O	O
614	1,4-Dichloro-1,2 dipivalyl ethane	No	O	O	O	O
751	3,3-Pentylidene *bis*-[5-(diethyl furfuryl)-furan]	No	O*	O*	O*	O*
752	2,2-Ethylidene *bis*-[5-(methyl furfuryl)-furan]	No	O*	O*	O*	O*
783	t-Butyl-dichloromercurifuran	Yes	O	O	F	F
782	Neopentyldimethylmethyl furan	No	O	O	O	O
781	1,1-Difurylethane	No	O	O	O	O

2,3-*Dihylrobenzo* (*f*)-1,4-*oxathiepins*

646	Unsubstituted	No	O	O	O	O
656	7,9-Dichloro	No	O	O	O	O
661	7-Methyl	No	O	O	O	O
657	7-t-Butyl	Yes	O	O	O	O
671	7-Nitro	No	O	O	O	O
669	7-5-Butyl-9-chloro	No	O	O	O	O
679	7-t-Butyl-9-nitro	No	O	O	O	O
684	7-Methyl-9-t-butyl	No	O	O	O	O
651	2,3-dihydro-6,7-benzo (f)-1,4-oxathiepin 4,4-dioxide (in 70% acetone)	Crystallized in nozzle				

DITHIOCARBAMATES

788	bis (p-Chlorobenzylmercapto) ethylene bis dithiocarbamate	No	O	O	O	O
789	p-Chlorobenzyl N,N-dimethyl dithiocarbamate	No	O	O	O	O
790	p-Nitrobenzyl N,N-dimethyl dithiocarbamate	No	O	O	O	O
791	p-Xylylene bis-N,N-dimethyl dithiocarbamate	No	O	O	O	O
795	Sodium N,N-dimethyl dithiocarbamate (in water)	No	O	O	O	O
796	Sodium N-benzyl dithiocarbamate (in water)	Yes	O	O	F	F
802	p-Chlorobenzyl N-benzyl dithiocarbamate	No	O	O	O	O
808	p-Chlorobenzylmercapto carbethoxymethyl N,N-dimethyldithiocarbamate	No	O	O	O	O
801	2-p-t-Butylphenoxyethyl N,N-dimethyl dithiocarbamate	No	O	O	O	O
803	2,4-Dinitrophenyl N,N-dimethyl dithiocarbamate (in 70% acetone)	No	O	O	O	O
804	2,2'-Diethylmercapto bis-N,N-dimethyldithiocarbamate (0.8% in 80% acetone)	Poor solubility, not tested				
806	Benzyl N,N-dimethyldithiocarbamate	No	O	O	O	O
810	N-p-Nitrophenyl N-dimethyl dithiocarbamate (in 100% acetone)	No	O	O	O	O

BENZYL CHLORIDES

528	3-Nitro-4-methylbenzyl chloride	Slight	O	O	O	O
660	2-β-Chloroethoxy-5-methyl benzyl chloride	Yes	O	O	O	O
658	2-β-Chloroethoxy-5-t-butyl benzyl chloride	No	O	O	O	O
659	2-β-Chloroethoxy-3,5-dichloro benzyl chloride	Yes	O	O	O	O
664	2-β-Chloroethoxy-5-nitro benzyl chloride	Yes	O	O	O	O
672	2-β-Chloroethoxy-3-chloro-5-t-butyl benzyl chloride	Yes	O	O	O	O

678	2-β-Chloroethoxy-3-nitro-5-t-butyl benzyl chloride	No	O	O	O	O
685	2-β-Chloroethoxy-3-t-butyl-5-methyl benzyl chloride	No	O	O	O	O
612	1-Chloromethyl-4 chloronaphthalene	No	O	O	O	O
504	2-(2,3-Dichlorophopoxy)-5-chloro benzyl chloride	Slight	O	O	O	O
	PHOSPHOROUS COMPOUNDS					
764	Ethyl bis (ethylxanthato) thiophosphinate	Yes	O	O	P	P
765	Ethyl bis (dimethyldithiocarbamato) thiophosphinate	Yes	O	O	O	O
763	Diethyl dimethyldithiocarbamato thiophosphonate	Yes	O	O	P	P
744	Dithoxythiophosphono N-phenyl dithiocarbamate (in 50% acetone)	No	O	O	O	O
714	Ethoxythiophosphono bis ethylxanthate	No	O	O	T	T
703	Diethylphosphono ethylxanthate	No	O	O	O	O
710	Ethylthiophosphono bis-N,N'-dimethyldithiocarbamate	No	—	—	O	O
700	Ethoxythiophosphono bis-N,N dimethyldithiocarbamate	No	O	O	O	O
702	Ethoxythiophosphono bis-N,N dimethyldithiocarbamate (in alcohol)	No	O	O	O	O
699	Diethoxythiophosphono butylxanathate	No	O	O	O	O
701	Ethoxythiophosphono bis-N,N dimethyldithiocarbamate (in alcohol)	No	O	O	O	O
	CYANURIC ACID DERIVATES					
778	Cyanuric chloride	Yes	O	O	O	O
792	Tri (chloromethylthio) cyanuric acid (in 100% acetone)	No	O	O	O	O
785	Tri (allylthio) cyanurate	Yes	F	F	O	O
799	Trichloroethyl cyanurate	No	O	O	O	O
812	Trimethyl cyanurate	No	O	O	O	O
813	Tri (2-hydroxyethyl) cyanurate	No	O	O	O	O
	MERCAPTANS					
561	2,4-Dichlorobenzyl mercaptan	No	O	O	O	O
560	3,4-Dichlorobenzyl mercaptan	No	O	O	O	O
575	2,4-Dimethylbenzyl mercaptan	No	O	O	O	O
585	α-Naphthylmethyl mercaptan	Yes	O	O	O	O
617	4-Chloronaphthylmethyl mercaptan	Slight	O	O	O	O
621	3-Phenylpropyl mercaptan	No	O	O	O	O
754	3-p-Chlorophenylpropyl mercaptan	Yes	O	O	O	O
545	p-Nitrobenzyl mercaptan	Slight	O*	O*	O*	O*
551	p,p'-Dichlorobenzhydryl mercaptan	No	F*	O*	O	O
535	2-p-Xylylene dimercaptan	Yes	O	O	O	O
683	2- (α-Pyridyl) ethyl mercaptan	Slight	O	O	O	O
711	p-Chlorophenyl mercaptoethyl mercaptan	Slight	O	O	O	O
737	Ethyl mercaptan	No	O	O	O	O
606	p-Nitrophenylethyl mercaptan	Slight	O	O	O	O
577	2-Phenylethyl mercaptan	Slight	O	O	O	O
625	3-chloro-6,β-chloroethoxybenzyl mercaptan	No	O*	O*	O*	F*
616	p-Chlorophenacylmercaptan	No	O	O	O	O
	MISCELLANEOUS					
517	3-Bromo-4-methoxybenzyl 2-chloroethyl ether	Slight	O	F	O	F
524	3-Nitro-4-methylbenzyl 2-chloroethyl ether	Slight	O	F	O	O
641	2-β-Chloroethoxybenzyl alcohol	Yes	O	O	O	O
665	2-Chloro-4-t-butylphenyl 2-chloroethyl ether	No	O	O	O	T
680	2-t-Butyl-4-methylphenyl 2-chloroethyl ether	No	O	O	O	O
640	2,4,5-Trichlorophenyl 2-chloroethyl ether	Slight	O	O	O	O
662	2-Acetyl-4-methylphenyl 2-chloroethyl ether	No	O	O	O	O
566	Trichloro-2-isobutene and isomer	No	O	O	O	O
601	1-Phenyl-3-bromopropane	No	O	O	O	O
607	N-Formylguanidine (in water)	No	O	O	O	O
609	Octadecyl benzoate	No	O	O	O	O
608	Chloroacetanilide (in 70% acetone)	Yes	O	O	O	O
629	p-Chlorobenzyl 2-chloroethyl sulfone (in 70% acetone)	No	O	O	O	O
633	o-Formylphenyl 2-chloroethyl ether	Slight	O	O	O	O
634	Methyl malurate (in 70% acetone)	No	O	O	O	O

643	1,2-bis (2,4,5-Trichlorophenoxy) ethane (0.5% in 100% acetone)	No	O	O	O	O
642	1,2-bis (2,4-Dichlorophenoxy) ethane (in 100% acetone)	—	O	O	Crystallized	
644	1,2-bis (2-Formylphenoxy) ethane (0.5% in 100% acetone)	No	O	O	O	O
663	bis (2-β-chloroethoxy-5-nitrophenyl) methane	No	O	O	O	O
670	p-Nitrophenyl 2-chloroethyl ether	Yes	O	F	P	P
677	2-Hydroxy-5-methyl-acetophenone	No	O	O	O	O
686	1,2-bis-p-Tolyloxyethane	No	O	O	O	O
687	2,4-Di-t-butylphenol	No	O	O	O	O
693	1,1,3-Trimethoxypropane	No	O*	O*	O*	O*
691	Sodium 2-mercapto-4-hydroxy-6-aminopyrimidine (0.5% in 70% acetone)	No	O	O	O	O
705	2-Chloro-4-t-butylphenyl 2-thiocyanatoethyl ether	Slight	O	T	O	O
706	3-p-Chlorophenylpropyl alcohol	Yes	—	—	O	O
707	3-p-Chlorophenylpropyl bromide	No	—	—	O	O
692	p-Nitrophenyl 2-hydroxyethyl ether (in 70% acetone)	No	O	O	O	O
717	p-Chlorobenzyl 1,2-divinyl sulfone	Yes	O	O	O	O
725	Amyl 1,2-dichlorovinyl sulfone	Yes	O	O	—	—
734	β-p-t-Butylphenoxyethyl bromide	No	O	O	O	F
747	1,1,2-Trifluoro-2-chloro-3-phenylcyclobutene	Slight	O	O	O	O
773	Ethylenethiourea (in water)	No	O	O	O	O
767	2-Chloro-3-cyanolepidine (0.5%)	Yes	O	O	O	O
766	6-Amino-5,8-dichloroquinoline (in 100% acetone)	—	O	O	Crystallized	
774	3,4-Dichlorobenzyl 2-thiocyanatoethyl ether	Yes	F	F	F	F
775	1,4-Dithiocyanato-2-butene	Yes	T	F	O	F
777	1-Benzoyl-3-carbethoxytetrahydro-4-pyridone	No	O	O	O	O
797	N,N-Dibenzylthiourea (in 30% acetone)	No	O	O	O	O
811	4-Chloro-3-nitroacetophenone	No	O	O	O	O
814	1,4-Dithiocyanato-2,3-dibromo butane (in 100% acetone)	Crystallized in nozzle				
815	5-Nitro-6-chloroquinoline	No	O	O	O	O
648	2,4-Dichlorophenyl 2-chloroethyl ether	Yes	O*	O*	P*	P*
555	2,4-Dichlorobenzylmercapto propionitrile	No	O	O	O	O
563	Diacetoacetylethylenediamine (in water)	No	O	O	O	O
604	p-Chloroacetophenone	No	O	O	O	O
637	p-Chlorophenylethanol	No	O	O	O	O
638	Ethylcyanoacetate	No	O	O	O	O
639	Ethylchlorocarbonate	No	O	O	O	O
655	10-Thiocyanoacetylphenothiazine (in 70% acetone)	Slight	O	O	O	O
696	p-t-Butylphenyl 2-chloroethyl ether	No	O	O	O	O
697	p-t-Butylphenyl 2-thiocyanoethyl ether	No	O	O	O	O
718	1,1,1-Trichloro-3-nitropropene	Slight	O	O	O	O
736	Diethyldisulphide	No	O	O	O	O
740	Ethylthiocyanate	No	O	O	O	O
768	β-Chloropropionitrile	Yes	O	O	O	O
794	1,1,3-Trimethyl cyclohexene (3)-one (5)	Slight	O	O	O	O
805	Dibutylphthalate[1]	No	O	O	O	O
723	Piperonylbutoxide[2]	No	O	F	O	O
592	p-Nitrobenzyl chloride	No	O	O	O	O
581	p-Nitrophenylethyl chloride	Yes	O	O	O	O
593	o-Nitrophenylethyl chloride	Slight	O	O	O	O
576	2-Phenylethyl chloride	No	O	O	O	O
631	4-Chloro-1-bromobenzene	Slight	O	O	O	O
611	4-Chloro-1-nitrobenzene	No	O	O	O	O
750	α-Chloroethylsulfuryl chloride	Slight	O	O	O	O
650	p-Chlorophenethyl chloride	No	O	O	O	O
668	p-Chlorophenethyl thiocyanate	Yes	F	F	F	T
800	Lauryl chloride	Yes	O	F	O	O
591	n-Dodecyl bromide	No	O	O	F	F
547	1,2-Dibromobutane	No	O*	O*	O*	O*
548	1,2-Dibromocyclohexane	Slight	O*	O*	O	O
549	α,β-Dibromo-3-chloropropane	Yes	O*	O*	O	O
649	1,2-Dibromoethylbenzene	No	O	O	O	O
856	Diazinone (o,2-isopropyl-4-methyl pyrimidyl-*O,O*-dimethyl phosphorothioate. See Literature cited (7).	No	T*	T*	T*	T*
540	p-Nitrophenyl methyl ether (in 100% acetone)	No	O*	O*	O*	O*

[1]Well-known repellent.
[2]Well-known synergist.

543	p-Chlorophenyl mercapto propionitrile	Yes	O*	F*	O*	O*
613	4-2-Dichloroacetophenone	Slight	O	O	O	O
544	2-Benzothiazolyl 2-chloroethyl sulphide	No	O	O	O	O
505	2,β-Chloroethoxy-5-chlorobenzyl 2-hydroxyethyl ether	Yes	O	O	O	O
506	5,8-Dichloroquinoline	Yes	O	O	T	T
525	5,8-Dichloroquinoline (0.5%)	No	O	O	O	O
546	4,4'-Dimethyl-3,3'-dinitrodiphenyl methane	No	O	O	O	O
676	S-(2-β-Chloroethoxy-5-nitrobenzyl isothiuronium chloride	No	O	O	O	O
635	p-Chlorobenzyl 2-thiocyanatoethyl sulphone (in 70% acetone)	No	O	O	O	O
529	2-Methoxy-5-nitro-α-chlorotoluene	Yes	O*	O*	O*	O*
530	p-Nitroanisole	Slight	O*	O*	O*	O*
531	Acrylonitrile (in water)	No	O	O	O	O
532	α-Chloroacrylonitrile	No	O	O	O	O
533	α,β-Dichloroproprionitrile	No	O	O	O	O
534	α-Chloro-β,p-chlorobenzylmercapto proprionitrile	Slight	O	O	O	O
523	3-Bromo-4-methoxy benzyl 2-hydroxy ethyl ether	Slight	O	O	O	O
507	3,4-Dichlorobenzyl 2-chloroethyl ether	Slight	O	O	T	T
526	3,4-Dichlorobenzyl 2-chloroethyl ether (0.5%)	No	O*	O*	O*	O*
508	3,4-Dichlorobenzyloxy ethanol	Yes	O	O	O	O
510	2,4-Dichlorophenyl acetate	Unstable formulation				
514	β-Chloroethoxymethyl-1-naphthalene	Slight	O	O	O	O
515	β-Hydroxyethoxy methyl-1-naphthalene	Yes	O	O	O	O
516	2-(2,3-Dichloropropoxy)-5-chlorobenzyl 2-hydroxethyl ether	Slight	O	O	O	O
518	4-Chloro-2-hydroxyphenylacetate	Slight	O	O	O	O
519	2,4.6-Trichlorophenyl acetate	Yes	O	O	O	O
520	α, α'-Dimethyl 4,4'-diacetoxy-diphenyl methane	No	O	O	O	O
501	Hexachlorobenzene (0.5%)	No	O	O	O	O
502	Dinitrodiphenylamine (in 100% acetone)	No	O	O	O	O
503	w,p-Dichloroacetophenone	Slight	O	O	O	O
552	p p'-Dichlorobenzhydrol (in 70% acetone)	Slight	O*	O	O	O
553	2'-Hydroxy chalcone (in 70% acetone)	No	O	O	O	O
554	7-Hydroxy-8-chloroisoquinoline (0.5% in 100% acetone)	No	O*	O*	O	O
538	2-(Trichloromethyl)-5,8-dichloroquinoline	No	O	O	O	O
537	1-Trichloromethyl-2-(5,8-dichloroquinolyl) ethene	No	O	O	O	O

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COMPARISONS IN APHICIDE EVALUATION[1]

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INTRODUCTION

None of the many theories of modes of action of insecticides permits the accurate prediction of the precise quantitative and specific toxicity of any new compound, so that until it has been ascertained that a compound is toxic, the quantitative determination of its presence by chemical assay is of limited value. The need is for a rational programme of chemical synthesis combined with a rapid and efficient bioassay method.

As we have tested several hundred compounds during the past three years, it has seemed appropriate to attempt to analyse and compare some of the results.

MATERIAL AND EQUIPMENT

Two species of aphids have been used: *Aphis fabae* (Scop.) and *Macrosiphum pisi*, (Harris)[2]

[1]No. 4 in a series of papers.
[2]See foot note in (5).

For spraying, apparently healthy adults of indeterminate age have been gathered from healthy growing bean plants, and maintained in Erlenmyer flasks until wanted, usually one hour later. Graphs presented in this paper indicate the variations in aphid response. Compounds of outstanding promise or those that gave anomalous results were always re-tested.

The apparatus for rearing the aphids in large numbers on the bean, *Vicia faba* L., and the Potter tower and its accessories have been described elsewhere (3,6). The Potter tower has proved a most efficient piece of equipment: it has been possible to test the compounds for contact effect, for residual film effect and for phytotoxic effect (4).

ORIGIN OF COMPOUNDS

Dr. M. Kulka and Dr. F. Stryk of the Dominion Rubber Company Research Laboratories, synthesized most of the compounds and have described them elsewhere (1, 2).

RESULTS

Number of Compounds tested

During the period under review 700 compounds have been screened. Of these, 97 were tested for contact insecticidal effect only; 299 were tested for contact and residual effect; and 304 for phytotoxic effect, as well as for contact and residual insecticidal effect. Lists have already been published (3, 4, 5).

TABLE 1

Comparison of terminal radicles using *M. pisi*. The table gives the assessments for the compounds listed at either side, using *M. pisi* as test insect.

O indicates less than 70% mortality, assessed as non-insecticidal.
F indicates 70% to 94% mortality, assessed as slightly insecticidal.
T indicates 95% to 100% mortality assessed as insecticidal or promising.

	Phytotoxic	Direct Spray	Residual Deposit	Residual deposit	Direct Spray	Phytotoxic	
⬡$CH_2CH_2SCH_2CH_2Cl$	yes	C	T	O	T	yes	⬡$CH_2CH_2SCH_2CH_2SCN$
⬡$CH_2CH_2CH_2SCH_2CH_2Cl$	yes	O	F	O	F	yes	⬡$CH_2CH_2CH_2SCH_2CH_2SCN$
Cl⬡$CH_2CH_2CH_2SCH_2CH_2Cl$	yes	O	O	O	T	yes	Cl⬡$CH_2CH_2CH_2SCH_2CH_2SCN$
Cl⬡$CH_2CH_2SCH_2CH_2Cl$	yes	O	O	O	O	yes	Cl⬡$CH_2CH_2SCH_2CH_2SCN$
Cl⬡CH_2SCH_2Cl	no	O	O	O	O	no	Cl⬡CH_2SCH_2SCN
Cl⬡$CH_2SCH_2CH_2Cl$	yes	O	O	O	T	yes	Cl⬡$CH_2SCH_2CH_2SCN$
Cl⬡$CH_2SCH_2CH_2CH_2Cl$	—	—	—	O	T	yes	Cl⬡$CH_2SCH_2CH_2CH_2SCN$
Cl⬡$CH_2SCH_2CH_2CH_2CH_2Cl$	yes	T	O	T	T	yes	Cl⬡$CH_2SCH_2CH_2CH_2CH_2SCN$
Cl⬡$SCH_2CH_2CH_2CH_2Cl$	yes	O	T	O	T	yes	Cl⬡$SCH_2CH_2CH_2CH_2SCN$
Cl⬡$SCH_2CH_2CH_2Cl$	no	O	O	O	T	yes	Cl⬡$SCH_2CH_2CH_2SCN$
Cl⬡SCH_2CH_2Cl	—	O	—	O	T	yes	Cl⬡SCH_2CH_2SCN
Cl⬡SCH_2Cl	yes	O	O	O	O	yes	Cl⬡SCH_2SCN
Cl, Cl⬡SCH_2CH_2Cl	—	O	—	—	O	yes	Cl, Cl⬡SCH_2CH_2SCN
Cl, Cl, Cl⬡SCH_2CH_2Cl	—	O	—	—	O	—	Cl, Cl, Cl⬡SCH_2CH_2SCN
Cl, Cl⬡$CH_2SCH_2CH_2Cl$	yes	O	O	O	T	yes	Cl, Cl⬡$CH_2SCH_2CH_2SCN$
Cl, Cl⬡$CH_2SCH_2CH_2Cl$	yes	O	O	O	T	yes	Cl, Cl⬡$CH_2SCH_2CH_2SCN$
Cl⬡$CH_2OCH_2CH_2Cl$	no	O	T	T	O	yes	Cl⬡$CH_2OCH_2CH_2SCN$
Cl, Cl⬡$CH_2OCH_2CH_2Cl$	—	O	—	F	F	yes	Cl, Cl⬡$CH_2OCH_2CH_2SCN$
$CH_2SCH_2CH_2Cl$ ⬡⬡ Cl	no	O	O	O	F	no	$CH_2SCH_2CH_2SCN$ ⬡⬡ Cl

Phytotoxicity

Of the 304 compounds tested for phytotoxic effect only 130 were *not* significantly phytotoxic.

Lindane

Throughout the work, lindane has been found to be an effective insecticide against both species of aphids even at very low concentrations. Experiments showed that it had no systemic effect. As a direct spray, however, it produced marked species-specificity in response, in that *A. fabae* was always more resistant to it than *M. pisi* (Fig. 1.). It was not so obvious when the aphids were exposed to residual deposits (Fig. 2). Further evidence of this species-specificity is given in another paper (5). In many of the other examples of species-specificity observed, *A. fabae* was the more susceptible.

Comparison of terminal radicles

It was noted that a terminal thiocyanate radicle seemed to confer marked toxicity. If this terminal position was occupied by a chloride radicle, the direct spray toxicity was decreased (Table 1).

Emulsions

During our routine work, as has already been described, a close check has been kept on the technique by including in each spray assay a number of check treatments. As a check on the cleanliness of the Potter tower and the potency of the emulsion used, an emulsion check (control) is sprayed in each assay (3, 4). Some results are given in Figure 4. In April 1955 the emulsion check caused unusually high mortality as a direct spray. The precise reason for this could not be determined. Possibly, the emulsion had broken and the benzene was exerting a toxic (vapour) effect, which under certain circumstances it had been found to do. The situation was remedied by discarding the offending sample of emulsion, and thereafter using a portion of the emulsion that was freshly prepared each week to formulate the compounds tested. In most of the period under review, the emulsifying agent was Emulfor EL, but see (5).

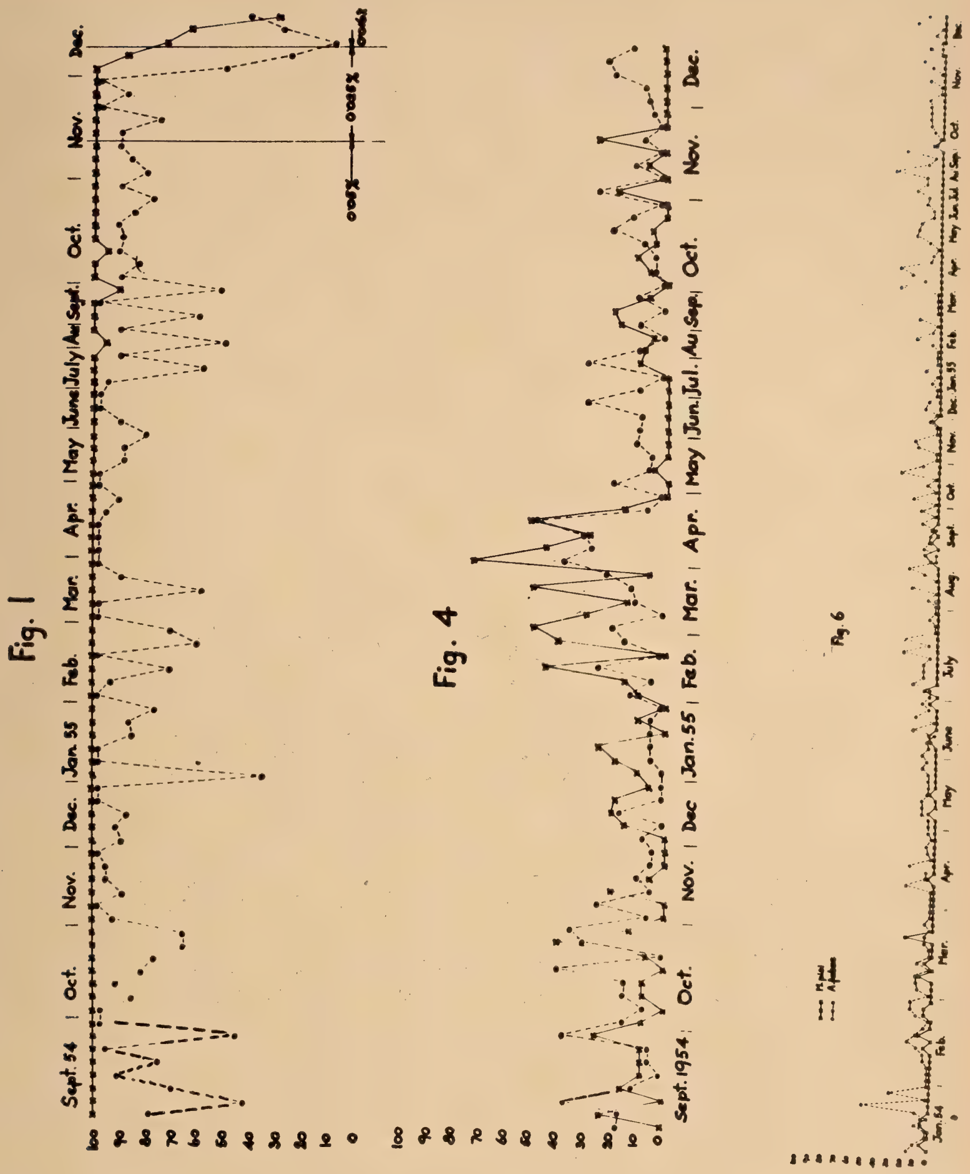
Variation in aphid susceptibility and behaviour

As a check on the strength of the stocks of aphids, a natural mortality check has been included in every test. The records for two years are shown in Figs. 5 and 6. It can be seen that *A. fabae* exhibits a more erratic and greater natural mortality than does *M. pisi.* In comparison with *A. fabae, M. pisi* is easier to collect and handle, as it readily drops from the plant; and its adult apterous form is more easily distinguishable from its nymphal forms. For these reasons it seems to be a better species than *A. fabae* for certain toxicological investigations.

REMARKS

The phenomen of species-specificity in response to insecticides and the, presumably related, phenomenon of development of resistance are attracting the attention of toxicologists at present. The observations suggesting that *A. fabae* is less susceptible than *M. pisi* to lindane is thus of interest in itself. It is the more interesting in that with other species-specific compounds, *A. fabae* was often found to be the susceptible species.

Caution must be exercised in drawing conclusions from the results compiled in Table I for they were mostly derived from single sprayings designed to detect outstandingly insecticidal compounds. However, the results do suggest that a terminal chloride radicle is much less insecticidal than a terminal thiocyante. This, of course, is not surprising. These results also suggest that the thiocyanates do not have much residual deposit toxicity; though there were two exceptions: the compounds P-$ClC_6H_4CH_2SCH_2CH_2CH_2CH_2SCN$, which was one of the very insecticidal compounds, and the compound P-$ClC_6H_4CH_2OCH_2CH_2SCN$. It should be noted that thiocyanates that were phytotoxic were not usually insecticidal as residual deposits. Thus, the residual deposit toxicity associated with the compounds cannot be regarded as an indirect

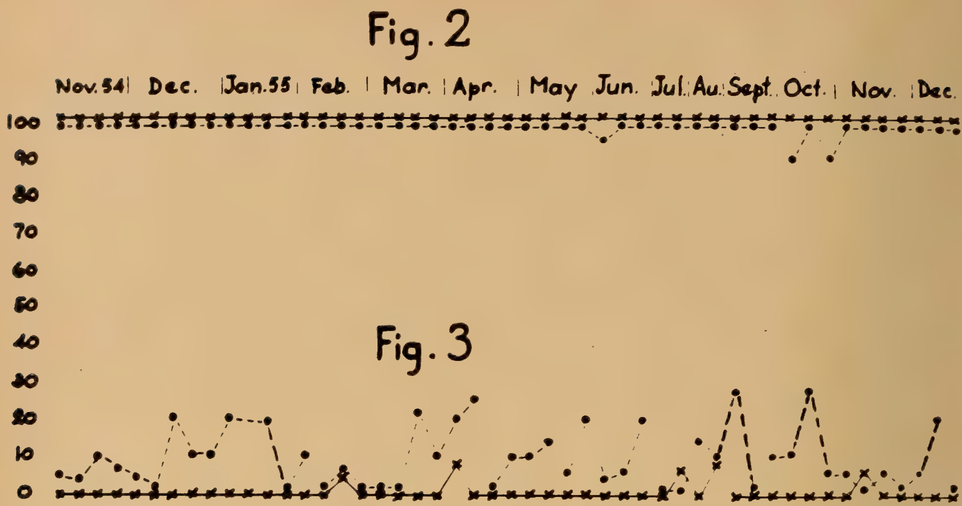


Figs 1 to 6 show the responses of *Aphis fabae* (broken line with dots) and *Macrosiphum pisi* (complete line with crosses) to various treatments.

Fig 1. Mortalities due to direct spray of lindane 0.05% concentration. Concentration reduced to 0.0165% during November/December 1955. 1 ml. volumes were sprayed.

Fig 4. Mortalities among aphids exposed to direct spray of standard benzene emulsion. 1 ml. volumes.

Fig. 6. Natural mortalities of aphids. (Check for those exposed to direct spray).



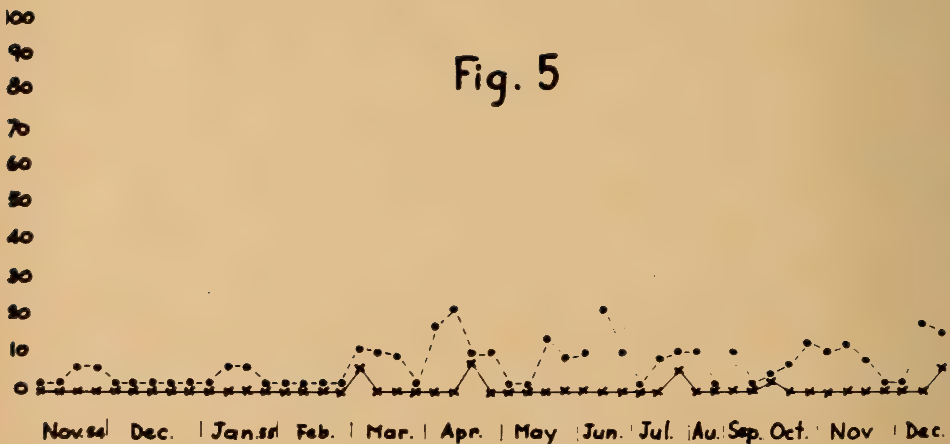


Fig. 2. Mortality among aphids exposed to residual deposit of lindane.

Fig. 3. Mortalities among aphids exposed to residual deposits of standard benzene emulsion.

Fig. 5. Natural mortalities of aphids. (Check for those exposed to residual deposits).

result of their phytotoxicity. This is confirmed by the interesting observation on the chloride, P-$ClC_6H_4CH_2OCH_2CH_2Cl$, which is not phytotoxic (in contrast to corresponding thiocyanate) and yet seems to have considerable residual effect toxicity. It will be noted that many of the chlorides, in contrast to thiocyanates, seem to be more toxic as residual deposits than as direct spray. The full explanation of this is wanting.

ACKNOWLEDGEMENTS

Thanks are gladly extended to Dr. W. E. Heming, Department of Entomology & Zoology, Ontario Agricultural College in whose Department we work, and to Dr. R. H. Manske of the Dominion Rubber Co. Research Laboratories, Guelph, for his co-operation and good-will.

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STUDIES ON THE BIOLOGY OF A CUTEREBRID (CUTEREBRIDAE: DIPTERA) INFESTING *PEROMYSCUS LEUCOPUS NOVEBORACENSIS*, FISCHER, THE WHITE-FOOTED MOUSE, IN SOUTHERN ONTARIO

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INTRODUCTION

Three families of warble or bot type Diptera are recognized by Curran (2): Oestridae, Gasterophilidae, and Cuterebridae. Their life histories comprise the egg, three larval instars, the pupa (enclosed in a hardened puparium), and the adult. The adult flies are usually short-lived, medium to large in size, very swift fliers, and are infrequently observed in nature. Adults and larvae of these three families can be distinguished readily on the basis of both morphological and biological characteristics. Some biological differences are: Gasterophilid third instar larvae localize in the wall of various parts of the digestive tract of horses, which they enter via the mouth directly or indirectly through the skin of the throat or lips. Oestrids infest only Artiodactyla and their third instar larvae generally are found in the nasal sinuses or in subcutaneous cavities on the back. They reach these localities by a migration through the somatic tissues after initial penetration of the skin. Cuterebrids occur in almost all orders of mammals except the Artiodactyla. *Dermatobia hominis* (L., Jr), though found in cattle and other animals, is however, a cuterebrid.

In August of 1953, a specimen of *P. leucopus*, infested with three third instar cuterebrid larvae was taken from a woodlot on a farm near Brantford, Ontario. Subsequently a woodland deer mouse, *Peromyscus maniculatus gracilis* Le Conte[1], captured in the kitchen of a farmhouse near Embro, Ontario, September 4, 1953, was brought to us. It was likewise infested with three third instar cuterebrid larvae.

[1]This identification is erroneous; should be **P. leucopus** (see also Fig. 3.)

Two woodlots on farms near Brantford were chosen for detailed studies for the summer of 1955. Though deciduous trees were found in both, they differed in several respects. Woodlot #1 was about four and one-half acres in extent and was in pasture through the previous summer. It was open, with a stand of sugar maple, basswood, red oak, white oak, ironwood, white ash, shagbark hickory and black cherry, and herb and grass cover. Woodlot # 2 was about two and one-half acres in extent and has been relatively undisturbed for some time. A small area at its west end has been used as a dumping ground. Ash and elm predominated and formed a dense canopy. The ground was bare and open for the most part, with some patches of dense shrubby undergrowth.

MATERIALS AND METHODS

Live-traps were laid out in the study areas in a grid pattern 45 feet apart. Trapping periods of three successive trap nights each were carried out as follows: June 20-24; July 4-7; July 25-28; August 8-11; August 22-25; and September 12-15. As mice were removed from traps, they were examined for any visible signs of larval infestation, marked by clipping the toes, and released at the point where they were caught. The location of the trap, the number of the mouse, its sex, breeding condition, and age were recorded. As the season progressed and evidence of infestation was seen, infested mice were removed to the laboratory. They were isolated, and weighed and examined daily.

Changes in the colour of the cuticle and morphology of the stigmal plates were useful indicators of the stage of development of larvae. The cuticle of first and second instar larvae was creamy white in colour. The cuticle of the late second instar and early third instar larvae was greyish-white, and the cuticular spines were tinged light brown. As third instar larvae matured, the cuticle and spines progressively darkened to a deep brown. The paired stigmal plates of the second instar larvae were perforated by two or three simple slits, which became complexly serpentine in the third instar.

As third instar larvae matured and emerged, they were replaced on the surface of moist sawdust in large ointment jars. They promptly burrowed beneath the surface, and formed puparia within a short time. They are being kept until adults emerge. White mice used in transplantation experiments were obtained from Ontario Veterinary College stock.

INCIDENCE OF INFESTATION

Thirty-five (28%) of 125 mice examined from four areas were found to be infested with second and third instar larvae (Table 1). An even higher percentage of infestation (54%) has been recorded in white-footed mice near Ames, Iowa (5). While the total numbers of mice trapped in the two Brantford woodlots differ, the numbers infested relative to total numbers examined do not appear to differ significantly. No percentage incidence is given in the table, since it is obviously impossible to determine the absolute incidence of this parasite in a population, because of the transitory nature of the infestation during the season. The difference in

TABLE 1 INCIDENCE OF INFESTED *P. LEUCOPUS* — 1955

AREA	Number of mice examined		infested		Total mice	
	M	F	M	F	examined	infested
BRANTFORD # 1	16	20	2	5	36	7
BRANTFORD # 2	41	41	8	13	82	21
DAIRY BUSH (OAC)*	3	3	3	3	6	6
ARKELL (de Vos* Woodlot)		1		1	1	1
Total	60	65	13	22	125	35

*Trapped irregularly.

the rate of infestation between males and females may be due to differences in the ages of infested mice and their differential seasonal behaviour. Since age determinations are not complete for all infested mice, no analysis of the possible significance of this factor can be made at this time.

HOST-PARASITE RELATIONS

The preferred location of the larvae was beneath the skin of either the right or left ventral surfaces at about the level of or posterior to the penis or clitoris (Figure 1). A total of 26 larvae (in both male and female mice) were found in the right ventral region, 25 larvae in the left ventral region. Only eight larvae were found in the median ventral region. Five larvae were located in three other regions (Figure 2): 1 in the pectoral ventral region, 1 in the middle of the right side, and 3 in the side and posterior to the hind limb. None was found in the small area between the anus and base of tail. Larvae located beneath the posterior ventral surface were usually oriented with their longitudinal axes parallel to that of the mouse, the apertures of the cavities (and posterior ends of the larvae) directed posteriorly. Presumably, the orientation and localization of these larvae in the mouse is restricted by limitations of space in such a small animal. Other orientations appear to be possible when the larvae are located in regions other than beneath the skin of the posterior ventral surface.

Of 35 infested mice, 23 harboured one larva; 6, two larvae; 2, three larvae; 1, five larvae; 1, six larvae; and 2, seven larvae. The mice averaged 1.6 larvae per animal.

The following observations were made on 26 mice in which the course of infestation was followed for periods up to seven weeks.

On the whole, infested *P. leucopus* did not seem to be seriously affected, as deduced by observations on their health and activity in the field and laboratory, and daily weights. In the laboratory, infested mice were as agile in eluding recapture as uninfested mice. However, when third instar larvae were close to emergence, thus much enlarged and protruding from cavities, the mice were obliged to keep one or the other hind limb raised as they ran.

Plots of daily weights of mice have not revealed a significant correlation between weight variation and the course of infestation. There appears to be some loss of weight for a few days prior to emergence of larvae but it is followed by recovery to about the same weight as when live-trapped.

The cavities in which the larvae developed were located subcutaneously with little or no involvement of the uderlying muscle tissue. With one exception, they were found to be completely walled-off. These observations are at variance with those of Dalmat (5) who stated: "The larval 'cyst' was not walled like that of the ox warbles, but was just an area in which necrosis of the muscle tissue had occurred." Actually, this was found to be the situation in laboratory white mice into which larvae from white-footed mice were experimentally transplanted.

After the larvae emerged from captive wild mice, the cavities almost always healed rapidly and cleanly, usually within three days. Within a few minutes after emergence of a larva, a colourless serous fluid exuded from the walls of the cavity. A short time later, the walls of the cavity collapsed and immediately adhered. Granulation and filling in occurred very rapidly, since within a day or two only a small depressed and healing area could be seen. No sign of the wound could be seen within another day or two, though the surrounding area might remain hairless for a week or more.

Various phenomena which might be interpreted either as secondary infections following emergence of larvae, or evidences of an immune response to the presence of larvae, were noted in some of the mice. Scabs resembling the skin puncture sites of young larvae were observed in mice with previous and concurrent larval infestations. However, no larvae were seen to develop further at those points. Sometimes one or more hairless areas appeared on the posterior

ventral surfaces of previously infested mice, and persisted for a period of two to six weeks, often accompanied by swelling. These events require further study to determine positively whether they are secondary infections following larval infestations or the accompaniment of the destruction of developing larvae beneath the skin by the action of an immune mechanism of the host.

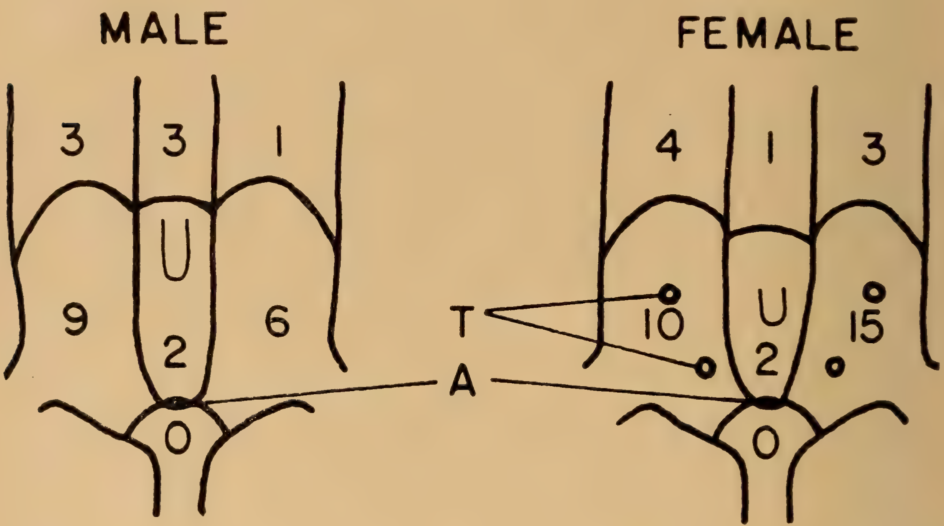

FIG. 1

Diagrams of ventral and lateral surfaces of *P. leucopus* (from four study areas, 1955) to illustrate locations and numbers of cuterebrid larvae. A = anus; T = teats.

One mouse bore a litter while harbouring two third instar larvae at different stages of development. The larvae were encased in separate and completely walled-off cavities lying side by side. The next day one of the larvae emerged. Shortly afterwards the mouse was found dead. The second larva, not yet matured, was extracted alive from its cavity without difficulty. A dark brown serous fluid was seen to be discharged in and around the cavity and the larva. The fluid had the same appearance as that observed in white mice into which larvae were transplanted.

Ordinarily, mice were placed on wire mesh well before emergence of larvae to allow emerged larvae to fall free of the mice. However, in some instances development of larvae was extraordinarily rapid and emergence occurred before expected. These larvae were quickly found by the mice in the cage litter and completely eaten, except for the cuticle.

In two instances third instar larvae were found to have been eaten *in situ* by mice. It is not known whether the larvae died or were eaten while still alive. The empty cuticles were sloughed within two days, and the cavities healed uneventfully.

Three mice bore litters while infested with larvae. These litters were not successfully reared. In one case, the location of the larvae appeared to interfere with the functioning of the teats. Successful litters were borne by two mice no longer infested by larvae at the time of and after bearing young.

Five voles (*Microtus p. pennsylvanicus* Ord), two short-tailed shrews (*Blarina brevicauda* Bole and Moulthrop), and one jumping mouse (*Zapus hudsonius* Zimmermann) were trapped in and around the two Brantford woodlots. None of these animals was infested with larvae at time of trapping.

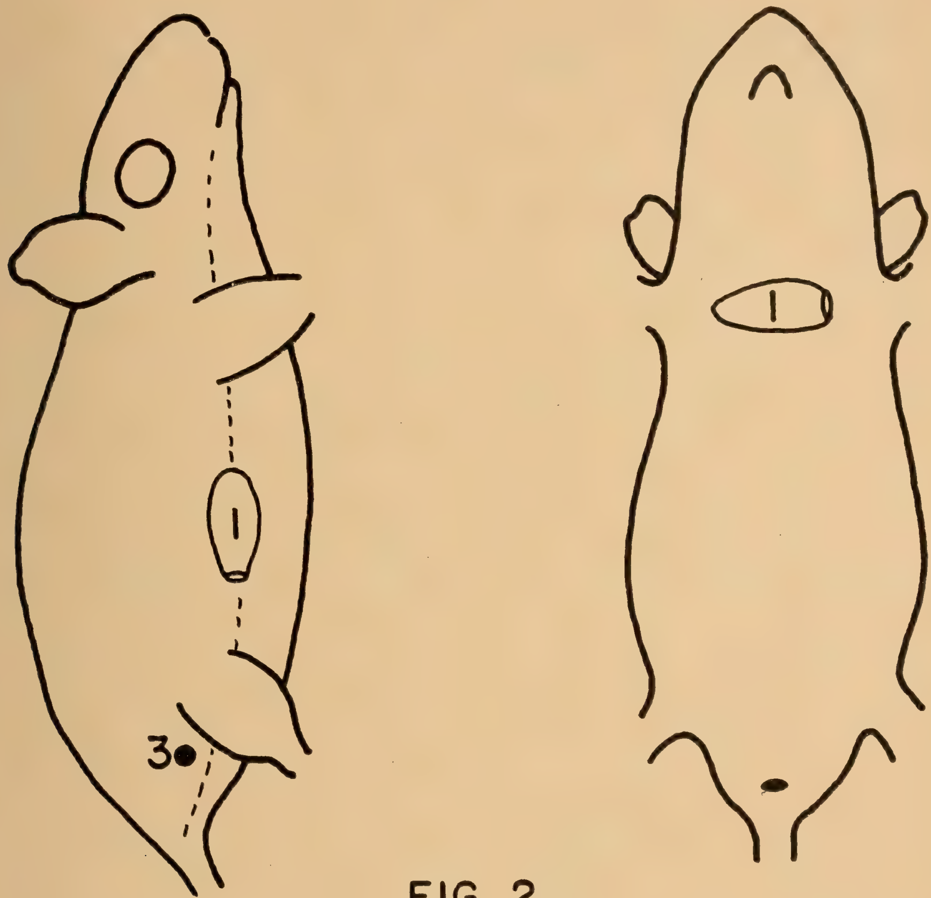

FIG. 2

See text, p. 91

TRANSPLANTATION EXPERIMENTS

Second and third instar larvae were removed from *P. leucopus* and inserted beneath the skin of the right or left posterior ventral surfaces of laboratory white mice, using the procedure outlined by Bennett (1). In only one instance did a larva successfully develop to maturity and emerge under these circumstances. In this case, a second instar larva, removed from a dead *P. leucopus*, was transplanted to the left inguinal region of an adult female white mouse. Six days later the mouse was noticeably thinner and moved sluggishly. At this time the opening in the skin was about three millimeters in diameter, and the larva was seen to be in early third instar. Nine days after the transplantation, a copious discharge of watery brown fluid in and around the caviety was seen. The mouse constantly licked at this. From the eleventh day, the mouse continued to lose weight and appeared to be sicker. The larva emerged on the thirteenth day. The mouse died on the sixteenth day. Autopsy disclosed that the lesion made by the larva had penetrated through the body wall, peritoneum and wall of the cecum.

The peritoneum and cecal wall had adhered to the body wall around the opening at the posterior end of the cavity. Subsequently second and third instar larvae were introduced beneath the skin of five other white mice. Invariably the mice sickened and died before the larvae could complete their development. A copious discharge of serous brown fluid in

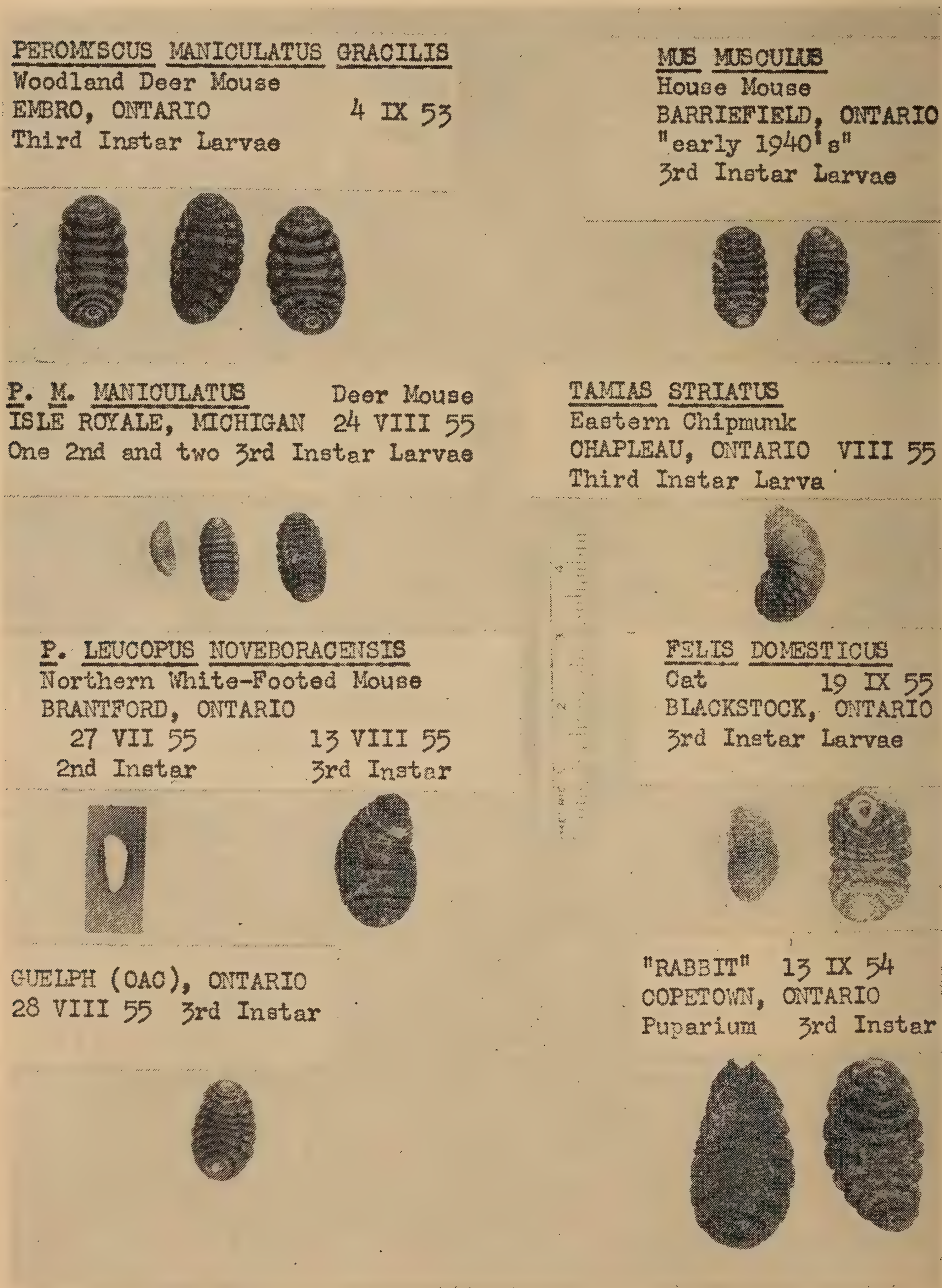

Fig. 3. Cuterebrid larvae from various hosts. A puparium is also shown.

and around the cavities was observed in all these cases. Thus it appears that white mice are not suitable for this type of experimental procedure as they exhibit little tolerance to the parasite.

SEASONAL LIFE HISTORY

Observations thus far permit the following tentative statement of the life history of the species studied to be made at this time: Adult flies hatch from puparia in June and July. Oviposition sites are where the hosts shelter or wander. Larvae hatch from the eggs and somehow reach their host while in early first instar. At this time they may be no more than a millimeter and a half long. They enter the host through the skin, and burrow in the subcutaneous tissues. They may remain near the site of initial puncture or wander elsewhere. It is not known if they are confined to the subcutaneous tissues. A few days later the larva becomes apparent through an opening in the skin which may be the same as the one through which it originally passed or a new one. Apparently, at this time a small amount of exudate is liberated which hardens into a small scab. The scab soon disappears and the posterior end of the young larva becomes visible through the opening, which may now be one millimeter in diameter. As the larva develops through second and third instars it increases greatly in bulk. Correspondingly the opening enlarges to three to five millimeters in diameter. As well, the surrounding area often becomes hairless and distinctly swollen. The matured third instar larva measures from 15 to 21 millimeters in length by 8 to 11 millimeters in width and weighs 0.6 to 1 gram or more. When matured, it emerges from its host, and soon becomes enclosed in a hardened puparium, within which it pupates.

A mouse trapped July 13 at the Arkell Woodlot harboured a single second instar larva. When this larva was transplanted into a white mouse, it emerged 13 days later (July 26). More second instar larvae were taken from mice trapped at Brantford July 27, and were found in mice trapped as late as August 11 at Brantford and the Dairy Bush (OAC). However, it is possible that first and second instar larvae in mice examined before July 13 might have been overlooked because of their small size and the inconspicuousness of the opening in the skin. In one instance, a scab was noticed on the skin of a mouse twenty days before the emergence of a mature third instar larva from the same site. In two other instances, larvae emerged ten and thirteen days after small openings in the skin were first detected. Thus, if it is assumed that a period of ten to twenty days elapses between puncture of the skin by the first instar larva and its development to second instar, some mice in these areas may have been infested during the latter half of June.

A third instar larva was first seen in a mouse trapped at Brantford July 28; it emerged nine days later (August 6). Third instar larvae were still noted in mice trapped as late as September 15 (the last trap day), and the last larva in the laboratory emerged from a mouse September 30. Some mice were apparently contacted by larvae as late as August. It appears, therefore, that the time of emergence of adult flies from puparia may extend over several weeks in June and July. The possibility of a second generation of flies during the season cannot, however, be discounted at this time.

DISCUSSION

The Cuterebridae are restricted to North and South America. In North America, the larvae of *Cuterebra* are rather common summer visitors in the subcutaneous tissues of dogs, cats and some other carnivores; rabbits; chipmunks, squirrels, house mice, deer mice, meadow voles, wood rats, and even muskrats (Fig. 3). Two cases have been recorded from man. Their natural hosts appear, however, to be rodents and lagomorphs. The larvae have become objects of popular curiosity because of their large size and their not infrequent occurrence in pet dogs and cats. Much of cuterebrid biology is unknown, including such basic information as oviposition sites, the manner in which the host acquires infestations, the early history of the larva in its host, and the feeding of the larva in its cavity. That infestations with certain dipteran larvae of similar habits (*e.g.*, the skin maggot or tumbu fly, *Cordylobia anthropophaga* Grünberg) evoke immune responses by the hosts is well known.

Similarly, cattle infested with warbles (*Hypoderma* sp.) definitely respond immunologically to the parasite. There is no information on the quality of the immune response of hosts to any species of *Cuterebra*.

How many true species of *Cuterebra* there are is unknown, since names have often been applied to a few specimens of larvae or adults unsupported by life history data. A complete life history performed under experimental conditions has yet to be demonstrated for any cuterebrid. That host specificity may be extremely narrow might be deduced from the fact that many species have been determined in part on the basis of host association. Yet larvae from different hosts often resemble each other closely in many details.

Whether these parasites have a direct influence on populations of their hosts is not known. However, when other organisms gain a foothold in the host tissues as a result of the prior activities of cuterebrid larvae, more serious effects may be produced. For example, it has been reported (6) that lesions in Texas cottontail rabbits caused by the rabbit bot fly, *Cuterebra buccata* F., are frequently invaded by the primary screwworm, *Callitroga americana* (Cushing and Patton), often with fatal results.

At least two species, *Cuterebra peromysci* Dalmat, and *C. angustifrons* Dalmat, have been described and named from the white-footed mouse at Ames, Iowa (3, 4). First, second, and third larval instars, the puparium and a single male were described for *C. peromysci*. *C. angustifrons* has been described only from a single adult male. Preliminary observations of the stigmal plates and cuticular spines of several second and third instar larvae indicate that the species studied here may be *C. peromysci*. Final identification awaits the examination of adults which it is hoped will emerge from puparia now being reared.

SUMMARY

Northern white-footed mice, *P. leucopus* Fischer, were systematically live-trapped from two woodlots near Brantford, Ontario, on eighteen trap nights during the period June 20 to September 15, 1955. Some mice from two other areas in southern Ontario were also examined. Thirty-five (28%) of the total of 125 mice from the four areas were found to be infested with cuterebrid larvae, which may be *Cuterebra peromysci* Dalmat. Second instar larvae were found in mice trapped July 13, but may have been present in mice some days earlier and overlooked. Third instar larvae were seen beginning July 28, and were still noted in mice trapped September 15. A period of ten to twenty days appears to elapse between time of puncture of the skin by the larva (presumably in middle of first instar) and its emergence from the host. Most larvae were found in subcutaneous and completely walled-off cavities beneath the right and left posterior ventral surfaces. Infested mice did not seem to be seriously affected by the presence of the larvae. Certain phenomena such as appearance of hairless areas accompanied by swelling were noted in some mice with concurrent or previous larval infestations. They are tentatively interpreted as either secondary infections or evidence of an immune response on the part of the host in the form of destruction of developing larvae beneath the skin. When second and third instar larvae were transplanted to six white mice, the mice sickened and died before the larvae could develop to maturity, with one exception. Five voles, two short-tailed shrews, and one jumping mouse, trapped in and around the two Brantford woodlots, were not infested with cuterebrid larvae.

ACKNOWLEDGMENTS

I wish to thank Mr. W. J. D. Stephen for technical assistance in all phases of this work; Drs. W. Lawrence, D. J. Price, and A. S. West for the contribution of some of the specimens shown in Figure 1; Dr. J. P. W. Gilman for many kindnesses; Mr. Gordon Bennett for much helpful advice; and Dr. W. E. Heming in whose Department the work was done.

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NOTES ON THE BIOLOGY AND LABORATORY REARING OF A PREDATORY INSECT, *ZELUS EXSANGUIS* (STAHL) (HEMIPTERA: REDUVIIDAE)[1]

A. S. West[2] and Barbara DeLong[3]

INTRODUCTION

The existing emphasis on experimental laboratory studies with insects is at times limited by the lack of a laboratory colony of a suitable insect. Studies in the fields of physiology, ecology, toxicology and biological control, for example, require that suitable insect species be maintained in the laboratory. It is probably true that many species could be reared under laboratory conditions but that such rearing has not been tried.

In our own laboratories, in connection with the development of the serological precipitin test as a means of evaluating the feeding habits of predaceous insects (Hall *et al*, 3), we desired to have available a predator which could be maintained with a minimum of effort. In the course of work at the Queen's University Biological Station at Lake Opinicon a reduviid, *Zelus exsanguis* (Stahl), was observed to be relatively abundant in surrounding areas. This paper reports observations of the insect under natural conditions and describes the method of maintaining a colony of the species during the winter months.

Taxonomic and distributional information and the inclusion of the species in an article on eggs of reduviidae (Readeo, 4) constitute the sole literature found in a limited search by the writers. Nothing was found on the life history or habits of the species. Blatchley (2, p. 570) gives the range of the insect as: from Quebec and New England west to the Pacific and south to Florida, Mexico and Panama, an dstates that Z. *exsanguis* is the most widely distributed member of the genus. During several seasons the species has been observed to be common in the Rideau Lakes region of Eastern Ontario. In 1953 it was common in the Muskoka district north of Toronto, Ontario. There is no reason to doubt that the species would be found in many other areas of the Province.

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[2]Professor of Zoology.
[3]Honour Biology Graduate, 1954.

DESCRIPTION

Adults

Z. exsanguis belongs to the sub-family Zelinae of the Reduviidae (Britton, 1). The adults are bright green to yellow in colour. The sexes are readily distinguished. In the male the hemielytra, pronotum and part of the head are dark brown or almost tan. Adults are approximately one-half inch or more in length with the males being slightly smaller than females.

The slender head tapers slightly posteriorly and is almost as long as the prothorax. In a resting position the distal part of the three-segmented beak lies in a ventral groove of the prothorax. Slender, four-segmented antennae are inserted near the mid-line of the head between the eyes and the rostrum. The sub-cylindrical compound eyes are small, but appear prominent owing to their bright red colour. Two ocelli are in a medial position posterior to the compound eyes. The pronotum is about as wide at its caudal end as it is long and there is a prominent spine situated on each side. The body is approximately five times the length ofthe head.

Eggs

The eggs are brown with a small white cap which has a hole in the center. Readeo (4) gives the size as: length 2 mm, greatest width .07 mm. The individual oblong or club-shaped egg when laid by the female is placed on end next to previously laid eggs. The closely grouped eggs are held together by an amber coloured cementing substance secreted by the female. The completed egg mass generally forms a somewhat regular five or six sided group.

Nymphs

The newly emerged nymph is pale yellow and approximately an eighth of an inch in length. It has the red eyes and the long, slender legs characteristic of the adult, but the body is only about twice the length of the head. There are five molts. With each succeeding molt the relative length of the body increases. In the second stadium the nymph acquires the bright green colour of the adult. Wing pads first are evident during the fourth stadium.

FIELD OBSERVATIONS

The following observations were made at Lake Opinicon during the summer of 1953. Adult female Z. *exsanguis* were present on 19 May when these studies were started. Males were found a few days later. Adults were common during June on the leaves of lower branches of broad-leaved trees and on the leaves of shrubs and saplings. They were particularly common along paths or roadways and on trees at the edg of a wooded area.

The adults move about slowly on the upper surface of leaves or crouch motionless when prey is near. If they are disturbed they quickly move to the underside of the foliage and remain motionless. With continued disturbance they either fly away or drop to the ground.

Capture of prey was observed on a number of occasions. The reduviid slowly stalks its prey and with a quick lunge grasps the victim with its spiny forelegs. The initial thrust of the beak does not kill or paralyze the prey as it does for certain Phymatids. Since death seemed to be related to the size of the prey it appears that the predator does not inject a toxin but kills the prey by sucking the body fluids.

During the 1953 season the forest tent caterpillar, *Malacosoma disstria* Hbn., was abundant in the Rideau Lakes region. Z *exsanguis* was frequently observed feeding on the larvae of the tent caterpillar. However, it is apparently a general feeder and probably does little if any host searching. Other prey observed in the field included representatives of the following orders and families: Diptera-Ortalidae?, Tipulidae; Hymenoptera-Braconidae; Coleoptera-Cantharidae, Scarabaeioidea and Lepidoptera-Geometridae (larva). Size of prey varied from very small Diptera to half-grown tent caterpillar larvae.

Although adults were found on 19 May they did not become common until the first week of June. At this time mating was observed and the first egg-mass was found. As egg masses appeared in greater numbers adult populations declined with the males disappearing first. The last adult was found on 2 July.

Egg masses were commonly found on foliage of ironwood, maple and basswood, most frequently in a shaded position. When the eggs hatch the nymphs remain close to the egg mass for as long as one-half hour. If a leaf was turned so that the newly emerged nymphs were exposed to the sun, all individuals quickly moved to the shaded side of the leaf. Gradually the nymphs disperse and come to lead a solitary existence.

Growth of nymphs in the field is slow and it seems probable that a heavy mortality occurs. By the first of September most nymphs had reached the fifth and final immature stadium which is apparently the overwintering stage. Only fourth and fifth stadium nymphs were found on October 11. These nymphs were sluggish and would not take proffered food. No adults were found in the fall. Six nymphs were placed in a carton with earth and leaf litter and held outdoors in a cage. Until freezing temperatures occurred the nymphs were frequently observed on the surface of the litter. No food was available during this period. In the latter part of November, following a period of temperatures below freezing and a severe storm which demolished the carton, one nymph was found still alive and active.

Little information was accumulated on enemies of Z. *exsanguis*. One nymph was observed being attacked by a spider after it had become entangled in the latter's web. In the laboratory a dipterous larva emerged from the abdomen of a field collected nymph which died on the following day. Through an error the parasite was not reared.

From the foregoing observations it is concluded that in nature there is but one generation a year and that the species overwinters as a full or nearly full-grown nymph. This conclusion is supported by the fact that nymphs which were collected in October and brought into the laboratory would not feed and did not molt to become adults.

LABORATORY STUDIES

Adults were collected in the field by tapping them into an ice-cream carton. For feeding experiments in the laboratory adults were confined individually in three inch shell vials with cotton plugs. For controlled mating and oviposition studies and for standard rearing pint ice-cream cartons with cheese cloth covers were used. To obtain a number of egg masses up to 20 adults, males and females, were held in a screen cage, 15" x 8" x 8". For mating and oviposition during the summer months fresh foliage was kept in the containers. During the summer months temperatures in the field laboratory approximated outside temperatures. When the study was moved to the University laboratory in September, the colony was maintained in an incubator at 80-86° and 70-80% relative humidity.

Feeding

During the summer months adults were fed on a variety of insects mostly collected by net-sweeping in a pasture. Representatives of the following orders and families were offered and were accepted by the adults. Diptera—Ortalidae, Muscidae, Syrphidae, Tabanidae, Tachinidae, Cordyluridae, Tipulidae and Asilidae; Hymenoptera—Anthrophoridae, Pompilidae, Ichneumonidae, Braconidae, Bombidae and Tenthredinidae (larvae); Hemiptera—Cicadellidae, Cercopidae, Miridae, Pentatomidae (nymph and adult), Membracidae, Nabidae (nymph and adult) and Reduviidae (nymph and adult of Z. *exsanguis*); Orthoptera—Locustidae; Odonata—Coenagriidae; Lepidoptera—unidentified moths and larvae. The foregoing list again indicates the general feeding of this predator. Any or all of this food appeared to be satisfactory as judged by longevity and oviposition records. Only ants, milkweed bugs, spiders and small, hard-shelled beetles were refused. All food was introduced in an active state. When relatively large insects such as bumble-bees or grasshoppers were introduced the reduviid remained quiet until the prey rested. If a large prey struggled when grasped the predator would release its hold to

return to the attack at a later time. Except for one predator which lost part of its beak during a struggle and was unable to feed thereafter the reduviid was always the victor.

Nymphs were fed on a variety of small insects during the summer months. Both during the summer and winter it was found that if first stadium nymphs were contained individually, even with a plentiful supply of prey, none survived. This fact, plus observed cannabalism when the nymphs of one egg mass were contained together, suggests that a special food is necessary for the new hatched nymph. Aphids were found to be particularly suitable for newly emerged nymphs as a supplement to cannabalism, but apparently were unsuitable for older nymphs. When second stadium nymphs were fed on aphids their bodies became yellowish and growth was retarded. When small leaf-hoppers were substituted the normal green colour returned. It seems probable that the kind of food may well affect rate of development. It is well-known that the first stage nymphs of certain predaceous Pentatomids feed on plant juices. *Z. exsanguis* nymphs were never observed to feed on plant material.

During the fall and winter months the variety of food available was much restricted. *Drosophila melanogaster* adults were fed to nymphs from hatching until the fifth stadium was reached. For the fifth stadium nymphs red pine sawfly larvae, removed from the cocoons, were supplied. Adults were fed on house flies.

Mating

Field collected adults were isolated in pairs, one male and one female, in pint ice-cream cartons. The male was left with the female until either mating was observed or the female became gravid. Mating occurred both in the dark and in the light. Some females had no doubt mated prior to being captured in the field. Studies showed that although a female would mate more than once, a single mating was sufficient for production of several masses of viable eggs and a second mating did not influence egg production. If the pair was left together after the mating the female sometimes ate the male even when other food was provided. Females ranging from two to 37 days of age were mated and no differences with respect to viable eggs were noted. A two-day old male was able to fertilize a female; after 27 days and four matings viable spermatozoa were still being produced by this same male. The single pair technique was followed in maintaining the colony and each egg mass was placed in a separate container.

Length of Life

Adults of the parent generation reared in the laboratory apparently lived longer than adults in the field. Outdoors the last adult was found on 2 July while in the laboratory the last adult of the same generation died on 17 August, 90 days after being collected. An adult of the F_1 generation in the laboratory also lived for 90 days.

Oviposition

Oviposition of an egg mass requires from one-half to one hour, depending on the size of the mass. A count of 12 field collected egg masses gave an average of 40 eggs per mass, ranging from 36 to 46. In the laboratory the number of eggs per mass seldom exceeded 30 and sometimes only five to 10 eggs were laid at a time. The number of masses laid by a female varied from one to five. No correlation of number of egg masses with longevity was apparent.

Egg Stage

During the summer months under variable temperature conditions eggs required from 10 to 12 days to hatch. For eggs of the F_2 generation held at a temperature of 80-86°F the time varied from seven to 21 days, with an average of 10 days for 32 egg masses. A few egg masses of the F_2 generation failed to hatch even though the female was known to have mated apparently normally. No infertile F_1 eggs were observed either in the laboratory or in the field.

Nymphs

Nymphs emerge by pushing aside the egg cap. Approximately an hour is required for total emergence from an egg mass. Frequently it was observed that the first emerged nymphs fed on the later emergents. This feeding was allowed in the standard rearing procedure.

In the laboratory two day old nymphs were placed in groups of 10-15 in pint milk bottles covered with cheese-cloth. After the first few days of nymphal life cannabalism was not a major factor. During the summer months fresh foliage was kept in the bottles. During the fall and winter no foliage was supplied and paper towelling was used to provide a resting place.

During the summer months the length of time spent in any one instar was extremely variable. For the F_2 generation the average duration of the five stadia, as recorded for eight nymphs, was 7, 8, 12, 18 and 11 days. The shortest development from egg hatch to adult for the F_1 generation was 88 days. For the F_2 generation, under relatively constant conditions the period was 84 days. Adults of the F_2 generation appeared in late January. F_3 eggs and nymphs were produced during February. These nymphs gave all evidence of constituting a thriving colony when it was necessary to discontinue the study at the end of March. Assuming a rate of development comparable to that for the F_2 generation F_3 adults would have developed during May.

SUMMARY

1. Notes on the biology and laboratory rearing of a predatory insect, *Zelus exsanguis* are presented.

2. It is shown that the species can be successfully reared in the laboratory and that a variety of hosts apparently provide suitable food.

3. Cannabalism is probably a necessary factor for first stadium nymphs.

4. Compared to one generation per year in nature, three generations can be produced in the laboratory.

5. The development of a method of maintaining this species in the laboratory provides another insect which is available for experimental laboratory studies. However, it is doubtful if the species would be adaptable to mass-rearing techniques.

ACKNOWLEDGMENTS

We are indebted to the Systematic Unit, Science Service, Ottawa, for checking the identity of the predator; to the Veterinary and Medical Entomology Unit, Ottawa, for providing house fly cultures; and to the Laboratory of Entomology, Belleville, for supplying a *Drosophila* culture.

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SCIENTIFIC NOTES AND COMMENTS[1]

THE ALFALFA WEEVIL IN NEW YORK

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The alfalfa weevil, *Hypera postica* (Gyll.), was first reported in the United States from a farm on the east side of Salt Lake City in the spring of 1904 (2). It continued to spread in the west until the insect was present in a large area covering thirteen states. Eastern alfalfa growers felt secure believing the weevil to be an inhabitant of the arid west and one that would not live or prosper well in the humid east. This did not prove to be so.

The problem in the east became apparent on April 14, 1952 (1) when taxonomists of the United States Dept. of Agriculture identified specimens collected in Anne Arundel County, Maryland, on July 14, 1951, as the alfalfa weevil. In June 1952, the junior author visited the investations near Bel Aire, Maryland to become acquainted with the problem, and preliminary surveys were undertaken in New York during the rest of that year.

During 1953 and 1954, extensive surveys were made throughout New York by the Department of Entomology of the New York State College of Agriculture in cooperation with plant inspectors of the New York State Department of Agriculture and Markets. Early surveys were made in legume fields, particularly those in alfalfa near race tracks and racing stables, as it was believed that the infestation in Maryland originated from western alfalfa imported as a special diet for race horses. Later scoutings were made in a more or less random manner. In none of these surveys was the alfalfa weevil found.

In late June 1955, the authors made an intensive scouting trip through Orange County, in southern New York, as the weevil had been reported from an area in Pennsylvania adjacent to Port Jervis, New York. On June 27, 1955, larvae of the alfalfa weevil were taken in net sweeps of alfalfa at Westtown. On that same day, other larvae were taken in net sweeps two miles north of Port Jervis on sweet clover, five miles east of Port Jervis on alfalfa, three miles east of Westtown on alfalfa, and one mile west of South Centerville on alfalfa. A total of only nine larvae were collected. No injury was noted and no adults were obtained. These records are believed to be the first concerning the distribution of this insect in New York.

The authors wish to thank Dr. W. H. Anderson of the Agr. Res. Serv. of the U.S.D.A. for identifying the larvae of the alfalfa weevil, Dr. B. A. App for his part in expediting this work, and Dieter W. Gump for aiding in certain phases of the work.

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THE POSSIBLE NATURE AND ORIGIN OF THE MYCETOMES IN THE *SITOPHILUS* WEEVILS

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In the larval stages of the weevils *Sitophilus granarius* (L), GG strain, and *Sitophilus oryza* (L) there occurs an organ commonly called a mycetome. It consists of a number of cells called mycetocytes which are, except in certain strains of *S. granarius* (5), full of characteristic micro-organisms (4, 5, 6, 7). During metamorphosis the mycetome apparently disintegrates into its constituent mycetocytes, which later, in the adult, become lodged in the caeca of the midgut (4). Three questions seem relevant. Is the mycetome an organ of hitherto unknown function that has become secondarily the lodging place of certain micro-organisms? Is it an hypertrophied growth of a pre-existing group of cells? Is the behaviour of the mycetocytes during metamorphosis of any particular significance?

In recent years it has been shown that metamorphosis in several orders of insects (Hemiptera, Neuroptera, Lepidoptera and Diptera) is under control of hormones secreted by neurosecretory cells in the region of the brain. These hormones act upon certain diffuse large-celled glands in the thoracic or anterior abdominal regions of the body (1). These glands apparently disappear during metamorphosis.

[1]Limited to 500 words: no graphs, tables or figures.—Ed.

The control mechanism of metamorphosis in the Coleoptera has not yet been described but it seems reasonable to suppose that it is similar to those already known.

The mycetomes of the *Sitophilus* weevils are located in the thoracic-abdominal region, are well supplied with tracheae and break up at metamorphosis. Moreover, there is some evidence that when not inhabited by micro-organisms they are reduced in size (3). The following tentative hypothesis is therefore presented in partial answer to the three questions posed above. That the mycetomes of the *Sitophilus* weevils are primarily endocrine glands, physiologically similar to the prothoracic glands in Lepidoptera (1), that have become secondarily a lodging place for micro-organisms which have developed a mutualistic association with the weevils and caused hypertrophy of the glands.

Further research will be needed to establish or refute this hypothesis.

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REVIEWS AND REPORTS

SUMMARY OF IMPORTANT INSECT INFESTATIONS, OCCURRENCES, AND DAMAGE IN CANADA IN 1955[1]

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This summary of insect conditions in Canada in 1955 was prepared from regional reports submitted by officers of the Entomology Division, provincial entomologists, officers of the Plant Protection Division, and university professors. In general, common names used are from the 1950 revision of the list approved by the American Association of Economic Entomologists. To avoid unnecessary duplication, forest insect conditions are not included, this being adequately dealt with in the *Annual Report of the Forest Insect and Disease Survey*, published by the Forest Biology Division, Canada Department of Agriculture.

GENERAL-FEEDING AND MISCELLANEOUS INSECTS

BEET WEBWORM.—No damage was reported.

BLISTER BEETLES.—Little damage was reported, but *Lytta nuttalii* Say was common on wild vetch at Brandon, Man., and *Epicauta pennsylvanica* (Deg.) occurred in small numbers on potato in Quebec.

CUTWORMS.—In British Columbia, infestations in the intereior were much lighter than during the previous three years. In the Thompson and Okanagan valleys various crops sustained light damage caused mostly by the red-backed cutworm, *Euxoa ochrogaster* (Guen.). Near Armstrong, considerable damage was done to watermelon seedlings grown on light sandy soil. In the Kamloops district, the red-backed cutworm and light infestations of the black

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army cutworm, *Actebia fennica* (Tausch.), and the dark-sided cutworm, *Euxoa messoria* (Harr.), occurred on asparagus and hops. At Rayleigh, the bertha armyworm, *Mamestra configurata* (Haw.), caused some local damage to the fruit of tomato. Similar damage at Spence's Bridge was caused by *P. margaritosa.*

In Alberta, the army cutworm, *Chorizagrotis auxiliaris* (Grote), caused severe losses in the Milk River, Coutts, and Bow Island districts in May and June. Flax, barley, alfalfa, and fall and spring wheats suffered some damage, but the greatest losses occurred in commercial mustard. Cool weather in late May delayed the period of maximum feeding about two weeks beyond normal. Populations were one to three per square foot. For the second successive season, the pale western cutworm, *Agrotis orthogonia* Morr., caused negligible damage.

In Saskatchewan, the army cutworm occurred in an unexpected and severe outbreak in southwestern districts during late May and June. About 18,500 acres of crop were infested, 10,000 acres of which were severely damaged. The area of infestation extended from Consul east to Val Marie and north to Shaunavon, Dollard, and Eastend. Almost all of the damaged crops were spring wheat seeded on summer-fallow. Larval populations in the fields sampled averaged 2.4 per square foot. One-third of the infested acreage had to be reseeded. Although most control measures were applied very late, recovery of 75 per cent was common. The crop was delayed at least a week. A heavy infestation of the bertha armyworm occurred on rape and flax in north-central and northeastern agricultural areas. The infestation was the heaviest and most widespread since 1948. In the Fenton-Birch Hills-Weldon area, 1,150 acres had field infestations averaging 10 to 20 larvae per square yard and damage averaging 9 to 28 per cent. Rape in this area was more severely damaged than was flax. Near Tisdale, in the northeastern agricultural area, approximately 5,000 acres of rape and flax were infested. Light infestations were reported in flax at Indian Head, and at Candiac in southeastern Saskatchewan. The red-backed cutworm was present in field crops in about the same small numbers as in 1954, causing slight damage. It occurred in several gardens on the lighter soils of the Nipawin area, but damage was not serious. At Saskatoon, for the first time in several years, there were no reports of damage in gardens. The pale western cutworm was less abundant than for many years. In a survey through west-central agricultural areas of the Province, a few larvae were found only in one field, at Stranraer. The wheat head armyworm, *Faronta diffusa* (Wlkr.), occurred in slightly greater numbers than in 1954. A few wheat fields in the Delisle area suffered minor damage. A boring cutworm, probably *Helotropha reniformis* (Grt.), occurred in potato stems at Somme, but damage was light. The armyworm, *Pseudaletia unipuncta* (Haw.), was not reported.

In Manitoba, there were no reports of damage in fields by the red-backed cutworm, but several garden infestations were recorded. The variegated cutworm occurred in small numbers at Oak Bluff and Beausejour. The black cutworm, *Agrotis ypsilon* (Rott.), caused minor damage to oats and barley at Beausejour and Glass. No reports were received of the pale western cutworm, the army cutworm, the armyworm, or the bertha armyworm.

In Ontario, cutworms were present in outbreak numbers in many vegetable crops throughout southwestern districts. Onions, carrots, red beets, corn, potatoes, melons, tomatoes, radishes, and asparagus suffered extensive damage. Two acres of carrots at Thedford and six acres of onions on Walpole Island were destroyed. Corn was commonly attacked, notably in Dover Township, Kent County. Infestations would have reached alarming proportions but for the extensive use of insecticides. Destructive infestations were reported also in Norfolk County in southern Ontario. In the eastern part of the Province, populations were smaller and damage was comparatively light. The armyworm, which occurred in a severe, general outbreak in 1954, caused some concern in southwestern Ontario, locally damaging cereal crops maturing rapidly as a result of near drought conditions, and moving into the margins of corn fields. Elsewhere in the Province only very minor damage occurred in a few local areas.

In Quebec, damage was general but was nowhere reported severe. The armyworm, although present in outbreak numbers in 1954, caused little concern.

In New Brunswick, the fall armyworm, *Laphygma frugiperda* (A. & S.), was numerous in the Scotchtown area and adults of the salt-march caterpillar, *Estigmene acrea* (Drury), were taken in large numbers in light traps. Adults of the armyworm, too, were numerous but larvae were very scarce. In Nova Scotia, the variegated cutworm and *Euxoa* and *Feltia* spp. occurred in normal, moderate numbers. The population of the bronzed cutworm, *Nephelodes emmedonia* (Cram.), in grassland at Cow Bay, Halifax County, remained at a low level, as in the previous five years. The fall armyworm was not reported and the armyworm was remarkably scarce, though it had been the outstanding pest in 1954. In Prince Edward Island a below-normal population of the variegated cutworm caused moderate damage to vegetables, the armyworm occurred in small numbers in a few grain fields, and the red-backed cutworm was not reported as a crop pest. In Newfoundland, infestations of the variegated cutworm caused moderate damage in the Bonavista Bay area; the black army cutworm, *Actebia fennica* (Tausch.), did some damage to cabbage transplants; and, as elsewhere, the armyworm, abundant in 1954, was little in evidence.

GRASSHOPPERS.—There was a marked reduction in grasshopper populations in British Columbia compared with 1954. Control measures were necessary to some extent in both the Nicola and Princeton grasshopper control zones and economic infestations occurred in the East Kootenays as well. From Clinton northward grasshoppers were almost a rarity. *Camnula pellucida* (Scudd.) was concentrated in considerable numbers in small patches in the Princeton and St. Mary's Prairie areas during June, but *Melanoplus mexicanus mexicanus* (Sauss.) was more widely distributed, particularly in the Nicola zone, and was generally the most abundant species. *M. bivittatus* (Say) was present in small numbers in southern districts and *M. bruneri* Scudd. occurred in very small numbers in areas where it had been abundant in 1954.

In Alberta, the hatches of *M. bivittatus* and *M. m. mexicanus* were each approximately two weeks later than in 1954. Moderately large populations of both species were present in the south-central agricultural areas. Roadside populations up to 100 nymphs per square yard were fairly common in July. No crop damage occurred as there was sufficient vegetation along the roadsides to maintain the population. Elsewhere in the Province grasshoppers were very scarce.

In Saskatchewan, grasshoppers were again of little importance. Chemical control was carried out in only a few isolated southwestern areas. The weather, however, was more favourable to grasshopper development and oviposition than in several preceding years. Surveys of adult abundance revealed a general increase, especially of *Melanoplus* spp., and tangible numbers were more widespread than in previous years. Though grasshoppers were expected to be more numerous in 1956 than in 1955, the outbreak potential was still restricted to very small areas, the most important being the Robsart-Consul district in southwestern Saskatchewan. *M. bivittatus* was the most abundant species in the Province as a whole, although *C. pellucida* was the important one in the Robsart-Consul area. *M. m. mexicanus,* although recovering slowly, was still at a low level of abundance.

In Manitoba, the adult survey revealed a marked increase in the abundance and distribution of the economic species. Infestations ranging from light to very severe were present in the Shilo-Treesbank district. Moderate and severe infestations existed south of the Neepawa-Gladstone district. A moderate infestation, encircled by a light infestation, was present in the Elm Creek-Carman-Graysville district. A light infestation was present east of the Red River. The infested area extended from St. Jean southeast to the International Boundary. The egg survey revealed moderate infestations in the Shilo-Treesbank, Neepawa-Gladstone, and Elm Creek-Carman-Graysville districts. A light infestation was present east of the last district. Fields and roadsides were infested. *M. m. mexicanus* was the dominant species, *M. bivittatus* and *M. packardii* Scudd. being secondary. Traces of *C. pellucida* were also present. A light infestation, covering approximately the area infested by adults, was present east of the Red River. The infestation in this area was confined to the roadsides. *M. bivittatus* was the dominant species, *C. pellucida* being secondary and *M. m. mexicanus* also present.

In Eastern Canada, grasshoppers were of minor economic importance. In general, numbers were average and distribution was irregular. However, in eastern Ontario some large, local populations were observed late in the season. *M. femur-rubrum* (Deg.), *M. bivittatus, M. m. mexicanus, C. pellucida,* and *Encoptolophus sordidus* (Burm.) are the most common species in Ontario.

JAPANESE BEETLE.—Trapping for this insect was continued on a reduced scale. Six hundred traps were used at Hamilton, Ont., and 400 at Windsor, Ont.; 216 beetles were taken at the former location and 249 at the latter. In addition, a few beetles were collected by scouts at Port Burwell and Fort Erie.

JUNE BEETLES.—In British Columbia, large numbers of adults of *Polyphylla perversa* Csy. and *Phyllophaga anxia* (Lec.) emerged in the Kamloops area in July. In the Prairie Provinces, Saskatchewan reported more white grubs than in the previous two years. Potatoes were damaged in the Stoughton and Nipawin areas and white grubs were numerous in a field of crested wheat-grass at Maidstone. No reports of damage were received from either Alberta or Manitoba. Little serious damage occurred in Ontario and Quebec, most larvae being in either the first- or the third-year stage. In New Brunswick many adults of *Phyllophaga* spp. were taken in light traps. In Nova Scotia damage to potatoes was reported from Hants, Inverness, and Guysborough counties. In Prince Edward Island and Newfoundland very little damage was reported.

INSECTS FEEDING ON WEEDS.—In British Columbia, *Trirhabda pilosa* Blake continued its attack on stands of sagebrush, *Artemisia tridentata* Nutt., in the area southwest of Kamloops. Another area of approximately 10 acres was completely defoliaged and the 15-acre tract defoliated in 1954 contained only dead plants. In Saskatchewan, a chrysomelid, *Gastrophysa polygoni* (L.), effectively controlled wild buckwheat in many areas, particularly in west-central Saskatchewan from Kindersley and Bounty north to Glaslyn. At the Experimental Station,

Scott, it destroyed plots of wild buckwheat being used in herbicide tests. The beetle was also reported from Rosthern, Laird, and Saskatoon in central Saskatchewan, and from Radville and Viceroy in the southeast.

WIREWORMS.—In British Columbia, a survey of the lower Fraser Valley showed that *Agriotes sparsus* Lec. was largely responsible for the wireworm damage to potato crops in the delta, 4 to 65 per cent of the tubers in untreated plots being affected. The species was first recorded as a pest in the area in 1948 and infestations are becoming more widespread and severe. In the Agassiz area, a five-acre field of sweet corn was severely damaged by *Agriotes obscurus* (L.). In the Vernon district, wireworms severely damaged about five acres of seedling onions and in the North Okanagan did minor damage to asparagus and potatoes generally. Damage to grain in the Peace River area was about normal, as were infestations in potatoes in the Cariboo area and in central British Columbia. A clover field near Prince George was severely infested, and in the Smithers-Terrace district the increased use of control measures reduced damage considerably.

Wireworm damage in southern Alberta was more serious than in 1954. Some winter wheat fields were thinned to the extent that they were plowed and re-seeded. General thinning occurred in untreated spring wheat fields. Some patchiness in sugar beets was attributed to damage by *Ctenicera aeripennis destructor* (Brown) and *Hypolithus nocturnus* Esch.

In Saskatchewan, wireworm damage to cereal crops was generally light and less than that estimated in 1954. Of 238 fields examined in a survey of the Province, 96 contained no damage, 57 a trace (0-2 per cent), 61 light (3-10 per cent), 21 moderate (11-25 per cent), and 3 severe (26-50 per cent); no fields were observed in which estimated thinning exceeded 50 per cent. Most of the severe damage occurred in spring wheat. The majority of the fields were in the central, northwest, west-central, and south-central agricultural areas, and on light or medium loam soil. Damage to oats, barley, rye, and flax in the heavier soil areas was generally very light, but some local damage occurred in wheat. *H. nocturnus* was more abundant than the prairie grain wireworm, *C. a. destructor,* in intensively sampled fields near Saskatoon and Swift Current; this relation was the reverse of that observed in 1954 and the same as in 1953, but the factors responsible for fluctuations were not determined.

In Manitoba, there were no reports of damage, the situation apparently being associated with heavy precipitation and rapid growth in May and June.

In southwestern Ontario, wireworms caused very little damage as most susceptible crops were protected by chemical methods. In untreated crops, the larvae in general were more destructive than in 1954. The eastern field wireworm, *Lomonius agonus* (Say), seriously damaged several fields of potatoes in the Ridgetown district. This species also damaged corn and burley and flue-cured tobaccos where protective measures were not used. *Aeolus mellillus* (Say) appeared to be more abundant than in the previous four years. No serious damage was reported elsewhere in the Province.

In Quebec, wireworms caused more damage than usual, especially to cereal and potato crops in the Eastern Townships. In the muckland areas about Ste. Clothilde and Hemmingford, 22 to 50 per cent of the tubers of potatoes were injured. In the St. Lawrence Gulf provinces, scattered light damage was reported from New Brunswick. In Nova Scotia, *Agriotes mancus* (Say) in Kings County, *A. sputator* (L.) in the Sydney and Digby areas, *A. obscurus* (L.) in the Halifax and Lunenburg areas, and *A. lineatus* (L.) in the Yarmouth area continued to be numerous and injurious to several crops. The rarely seen species *A. collaris* (Lec.) was collected at Kentville. No reports of damage were reported from Prince Edward Island, but in Newfoundland infestation continued to be heavy in the Avalon Peninsula where control materials were not used.

FIELD CROP INSECTS

APHIDS.—No outbreaks of grain aphids were reported in British Columbia, although the English grain aphid was present in all grain fields in the north Okanagan and Kelowna areas and populations in the Golden-Edgewater area were the largest in several years.

In Alberta, several species of aphids were extremely abundant throughout the Province. The outbreak was the most serious and spectacular ever experienced. Barley, wheat, oats, and rye were all infested, but late-seeded barley was the only crop that suffered severe loss and, because of the late spring, there was a large acreage seeded. *Macrosiphum granarium* (Kby.), *Toxoptera graminum* (Rond.), *Rhopalosiphum maidis* (Fitch), *R. pseudobrassicae* (Davis), *Macrosiphum pisi* (Harris), *Myzocallis trifolii* (Monnell), *Macrosiphum ambrosiae* complex, and *Rhopalosiphum fitchii* complex were all present, but the first three species named were most abundant. Although large aphid populations were present on the heads of wheat no observable damage occurred. In Saskatchewan, the corn leaf aphid, *R. maidis,* attacked practically all late-seeded barley. This was the first outbreak of this species and undoubtedly the worst

aphid outbreak ever experienced in the Province. The greatly increased acreage of barley (from 2,313,000 acres in 1954 to 3,846,000 acres in 1955), resulting from unfavourable wheat seeding conditions, and the late seeding of the barley contributed greatly to the seriousness of the problem. Also, weather conditions were believed to have been near optimum for development of the aphids. An estimated 100,000 acres of late barley was destroyed and later plowed down and a substantial acreage was partially damaged. Approximately 64,000 acres were sprayed with malathion and many more fields would have been treated if material had been available. Infestations were most severe and general in the northern, central, and east-central crop districts, where the proportion of late seeding was greatest, and least serious in the west-central and southwest districts, where seeding was less delayed. Populations ran as high as many thousands of aphids per plant and heavily infested fields were a mess of stickiness from the excessive secretion of honey dew. Wheat and oats adjacent to very heavily infested barley were very lightly infested, if at all, regardless of the stage of development. Corn was not noticeably attacked at the time of the outbreak on barley, but by mid-August sweet corn throughout the Province was infested by this aphid. The English grain aphid, *M. granarium,* was present only in small numbers on heading oats and wheat. The greenbug, *T. graminum,* damaged volunteer wheat seedlings in a few fields of weedy summer-fallow in the Saskatoon district and light infestations occurred in some severely retarded barley stands that earlier had been infested by the corn leaf aphid. *Brachycolus tritici* Gill. was again abundant on new plantings of intermediate and crested wheat-grass on experimental plots at Saskatoon.

In Manitoba, the aphid outbreak affected the whole agricultural area of the Province and was the severest since 1949. Small populations of the greenbug occurred early but did not build up. The English grain aphid then occurred in considerable numbers, but the corn leaf aphid was the dominant species. It was the first time this species had occurred in an extensive outbreak. A small outbreak occurred in the Dauphin area in 1954. About one-tenth of the barley acreage, or 270,000 acres, was sown late. Most of this was infested and a great deal completely destroyed. Other grain crops were not seriously infested. Later, aphids were numerous on sweet corn, especially in the Winnipeg area.

Infestations occurred over all of south-central and eastern Ontario, late barley being most severely attacked, and in southwestern Ontario an outbreak of the English grain aphid affected wheat, oats, barley, and rye. Over-all losses, however, were small. Light infestations of the corn leaf aphid caused minor damage to corn in Essex and Kent counties.

In Quebec, the corn leaf aphid occurred on barley in a general outbreak throughout eastern districts and in abundance throughout the Richelieu and Yamaska valleys. Where barley and oats were mixed, the oats was only slightly infested. In varietal plots of barley at La Pocatiere, some varieties were severely infested whereas others had only trace infestations. The English grain aphid also occurred, infesting oats near St. Jean.

In New Brunswick, control measures were necessary in many grain-growing areas, notably in the upper Saint John River Valley. Species in the Fredericton area were, in order of abundance: *R. maidis,* the *R. fitchii* complex, and *M. granarium.* In the southern part of the Province, only *M. granarium* and *R. maidis* were present, whereas in the northern part the *R. fitchii* complex, *R. maidis,* and *M. granarium* were the main species. *R. maidis* was prevalent on barley, but the *R. fitchii* complex and *M. granarium* were more numerous on oats. *R. maidis* was present in light infestations in all corn fields examined, but damage was negligible.

In Nova Scotia, aphids were the outstanding grain pests of the season and oats and barley generally were severely infested. A few late stands of grain were ruined but maturity of the crop, disease, parasites, an dpredators usually prevented excessive reduction of yield. *M. granarium, R. maidis,* and the *R. fitchii* complex were identified from oats.

In Prince Edwards Island populations built up to a high level in many grain fields, causing severe damage to late-planted barley. The species infesting barley were *R. maidis* and *M. granarium.* Those on oats were *Sipha agropyrella* H.R.L. and the *R. fitchii* complex.

The pea aphid was much less numerous than in 1953 or 1954 in Manitoba, control measures being necessary only in a few very late plantings, mainly of soup peas near Portage la Prairie and Dugald. In southwestern Ontario, some 2,000 acres of canning peas in Kent and Essex counties were infested in varying degree, some requiring control measures. In southwestern Quebec, a large acreage of peas was sprayed but, in general, infestation was light. In New Brunswick the pea aphid was nowhere sufficiently numerous to warrant control measures, but in Nova Scotia heavy infestations made control measures necessary for the first time in many years.

In Saskatchewan, some new varieties of rape in experimental plots were severely infested with the cabbage aphid, adversely affecting seed production.

Predators of aphids, notably coccinelid and syrphid larvae, became very numerous in most aphid-infested grain fields across the country during the latter stages of the outbreak.

BARLEY JOINTWORM.—In Prince Edward Island, *Harmolita hordei* (Harr.) caused moderate damage to barley in the New London area. Elsewhere in the Province, damage was light. The infestation is gradually moving westward in the northern part of the Province.

CHINCH BUG.—A few fields of corn in Essex County, Ont., were sufficiently infested at wheat harvest by *Blissus leucopterus* (Say) to require control measures. Small numbers were observed in many corn fields in southwestern Ontario.

CLOVER SEED MIDGE.—Larval infestations of *Dasyneura leguminicola* (Lint.) were common in most red clover fields in the Ottawa, Ont., area. Populations in June were larger than in 1954, but the dry summer was not favourable for continued increase. No midge damage was found in red clover fields examined in late August.

CLOVER-INFESTING WEEVILS.—Although still not common in infested areas of Alberta, the alfalfa weevil, *Hypera postica* (Gyll.), was much easier to find than in 1954, when it appeared at Manyberries, Alta., for the first time in Canada. As yet, no infestations have been found north of the Oldman River. Found for the first time also in Saskatchewan in 1954, the weevil appeared to have spread eastward from southwestern and south-central areas of the Province. In 1955 very light infestations were found as far east as Stoughton, Sask., about 65 miles west of the Manitoba border, whereas in 1954 none was found east of Ogema, about 155 miles west of this border. None have been found farther north than about 100 miles from the International Border. Infestations in Saskatchewan have not yet approached economic levels. A weevil, *Sitona tibialis* (Hbst.), was again observed in many alfalfa fields in north-eastern Saskatchewan, but no appreciable damage was noticed.

The sweetclover weevil, *Sitona cylindricollis* Fahr., caused minor damage in Alberta, where a cold, wet spring permitted the crop to get ahead of the weevil. Large numbers in Saskatchewan caused the only damage of economic importance to this crop. In Manitoba, very large populations of overwintered adults appeared in second-year clover in May. As a result of good growing conditions, however, the plants outgrew the damage. Attacks on seedling sweet clover were common in southern Ontario, but little late damage was reported.

CORN EARWORM.—A light infestation of *Heliothis zea* (Boddie) (=*H. armigera* (Hbn.) at Nakusp, B.C., was the only one reported in the Province. In Alberta, the most severe infestations in recent years occurred at Medicine Hat, Scandia, and Barnwell. Light damage was reported at Craven, Fiske, and Swift Current, Sask. In Manitoba it was abundant in the Brandon, Portage la Prairie, and Winkler areas. Cob infestation ranged as high as 50 per cent in fields at Portage la Prairie and 20 per cent in the other areas. In southwestern Ontario, infestation was greatly reduced from that of 1954, only a few fields in the Tecumseh area and one on Pelee Island requiring treatment. In eastern Ontario a sharp increase in numbers was noted, especially in Prince Edward County. At St. Jean, Que., five per cent of the ears were infested in experimental plots. Considerable late-season damage occurred in New Brunswick, check plots at Maugerville showing up to 90 per cent ear infestation. In Nova Scotia a moderate infestation occurred in mid-season varieties of corn. Little injury was reported in Prince Edward Island, but in Newfoundland some severe, local damage occurred.

EUROPEAN CORN BORER.—In Saskatchewan, the area infested by *Pyrausta nubilalis* (Hbn.) increased 30 to 50 miles north and 50 miles west of the area infested in 1954. The northern boundary of the infestation ran from Melville to Lanigan, north of the Qu'Appelle Valley, and the western boundary was 50 miles west of the Third Meridian. Garden infestation was only sporadic in 1954, but in 1955 almost every garden examined was infested. Isolated infestations in the Yorkton-Kamsack area also were more widespread than in 1954. At Saskatoon, all truck farms were infested, although none had been in 1954. Populations ranged from 1 to 12 larvae and pupae per infested plant throughout the infested area. In the extreme southeast the plots examined had 10 to 90 per cent of the plants infested. Infestation in Manitoba, too, was undoubtedly the heaviest on record, although confined mainly to early sweet corn. Cob infestation ranged up to 40 per cent in the Winnipeg area and up to 50 per cent in the Brandon area. In Ontario a tremendous upsurge in numbers occurred in southwestern counties, Essex and Kent suffering severe infestations. Population counts were the highest since 1949, although counts in 1954 had been the second lowest on record. By contrast, only light infestation was reported in eastern Ontario. In Quebec, infestation was generally light, although stalk infestation ranged from 35 to 86 per cent in a few severely infested fields of canning corn in the St. Jean area. Inspection of corn in 11 Montreal canning factories revealed an average cob infestation of 24.6 per cent. In New Brunswick the borer was common in all corn-growing areas but damage was light. A general increase in numbers was reported in Nova Scotia and damage was usually severe where insecticides were not applied.

FLEA BEETLES.—Argentine rape in experimental plots at Winnipeg, Man., was severely infested by *Phyllotreta* spp., but little damage occurred in field plantings in the interlake area. In southwestern Ontario, the pale-striped flea beetle caused some light, local damage to soybeans.

HESSIAN FLY.—Generally light infestations of *Phytophaga destructor* (Say) extended throughout southern Alberta on both fall- and spring-seeded wheat. In Saskatchewan, a light infestation was reported in a field at Delisle and in Manitoba one was reported from Harding. In southwestern Ontario, a severe local infestation occurred in a field near Kent Bridge, but damage in general was not serious.

LEGUME-POLLINATING INSECTS.—In Alberta, *Megachile perihirta* Ckll., *M. dentitarsus* Sladen, *Bombus nevadensis* Cress., *B. fervidus* (F.) and *B. borealis* Kby. were the principal pollinators of alfalfa. Abundant native bloom on the prairie, favoured by heavy rains in early July, competed with alfalfa for the services of these native bees and they did not move into alfalfa fields until early August. It was expected, therefore, that seed set would be adversely affected in many areas. In Saskatchewan, observations on the abundance of native pollinators were limited to a few northeastern agricultural districts. *Megachile* spp., where present, appeared to be in about the same numbers as in previous years. *Bombus* spp. varied considerably in abundance from district to district as in most years. In the Wanless, Man., area, the leaf-cutter bees *Megachile frigida* Sm., *M. inermis* Prov., and *M. relativa Cress.* appeared earlier and in greater abundance than in 1953 or 1954. The population was at least double that of 1954 and the seed set in alfalfa was considerable. The bumble bees *Bombus terricola* Kby., B. *ternarius* Say, *B. vagans* Sm., and *B. fervidus* (E.), were observed. *B. terricola* was the most abundant, the population, 0.75 per square yard in alfalfa, being three times that of the previous two years. The other three species were scarce. *Anthophora* sp., which was common at Wanless in 1953, and scarce in 1954, was not observed in 1955 on alfalfa, but a few were seen on red clover. In eastern Ontario, exceptional numbers of bumble bees, *Bombus* spp., were present in the Marmora area, especially in late summer, and yields of clover seed were very good.

MEADOW SPITTLEBUG.—*Philaenus leucophthalmus* (L.) was again present in large numbers on alfalfa and clover throughout southwestern Ontario, but an accurate estimate of damage was impossible. Populations were noticeably reduced from those of previous years in eastern Quebec.

PEA MOTH.—In British Columbia, small numbers of *Laspeyresia nigricana* (Steph.) were reported in the lower Fraser Valley. Infestation was fairly general in the Ottawa, Ont., area and severe damage occurred in the Maugerville and Moncton, N. B., areas. The species was rare on canning peas in Nova Scotia, but 20 per cent of the pods were infested in a patch of vetch at Truro. In Prince Edward Island, garden peas were moderately damaged and field peas less than one per cent infested.

PEA WEEVIL.—Although *Bruchus pisorum* (L.) was present in British Columbia throughout the pea-growing area, centring on Armstrong, infestation averaged only one to two per cent. In Ontario, an infestation in canning peas in the Exeter area of Huron County resulted in 100 acres being condemned for canning purposes. The peas, which were allowed to ripen in the field, were 16 per cent infested in storage in early September. The infestation was the most severe on record in southwestern Ontario.

PLANT BUGS.—A few locally severe infestations of *Adelphocoris superbus* (Uhl.) and *Liocoris* (=Lygus) spp., chiefly *L. unctuosus* Kelton and *L. borealis* Kelton, were present in economic numbers in every field visited and caused severe damage in many areas. They were numerous also in red clover fields, but their importance as a pest of red clover is not known. *Adelphocoris lineolatus* (Goeze), which was recorded in economic numbers in Saskatchewan for the first time in 1952 in the Hudson Bay district, about 30 miles west of the Manitoba border, was abundant enough to cause serious damage as far west as Wierdale, about 145 miles from the Manitoba border. *Adelphocoris rapidus* (Say) was again present in many alfalfa fields, but only in small numbers. *Plagiognathus* sp., first recognized as a potential pest of alfalfa in 1947 and found causing severe damage in scattered fields in northern agricultural areas of Saskatchewan and Alberta in subsequent years, appeared somewhat reduced in numbers. At Wanless, Man., in a field of Ranger alfalfa sampled annually from 1952 to 1954 the population had steadily increased; in 1955 it was so heavy (up to 14 bugs per sweep) that blooming was prevented until August, when the population commenced to decrease. The main species present were *A. lineolatus* and *A. rapidus.* Other species in increased numbers included *Liocoris lineolaris* (Beav.) [=*Lygus oblineatus* (Say)] and *Liocoris* (=*Lygus*) spp. In the Ste. Anne de la Pocatiere area of Quebec, *L. lineolaris* was very numerous in clover and alfalfa fields.

SAY STINK BUG.—Populations of *Chlorochroa sayi* Stal increased for the second successive season in Alberta. Light infestations occurred in wheat fields in the Barnwell-Taber districts.

SIX-SPOTTED LEAFHOPPER.—Large populations of the *Macrosteles fascifrons* (Stal) complex in Manitoba were believed responsible for numerous cases of aster yellows in flax.

SUNFLOWER INSECTS. — In Manitoba, the sunflower moth, *Homoeosoma electellum* (Hulst), was present in small numbers throughout the sunflower-growing area. The banded sunflower moth, *Phalonia hospes* (Wlshm.), remained at a low population level and damage was only slightly greater than in 1954. *Chelonus* sp. near *shoshonearnorum* Vier. and *Glypta* sp. were again the important parasites of *P. hospes.* Cutworms caused no damage and the painted-lady, *Vanessa cardui* (L)., was not noted. A field near Brandon showed slight damage by *Phyciodes gorgone* Hbn. *Eucosma* sp., probably *pulveratana* Wlshm., was not observed. The sunflower beetle, *Zygogramma exclamationis* (F.), caused no significant damage. A predator of the sunflower beetle, *Lebia atriventris* Say, was present in the usual numbers. The sunflower maggot, *Strauzia longipennis* (Wied.), appeared to be more numerous in the adult stage than in 1954. Throughout the main sunflower-growing area, 87.9 per cent of the stalks surveyed showed damage, as compared with 66.8 per cent in 1954. Trypetids, *Oedicarena diffusa* Snow. and *Euarestoides finalis* (Loew), were present in numbers comparable to those of 1954. The ragweed plant bug, *Chlamydatus associatus* (Uhl), was present in reduced numbers. *Liocoris* (=*Lygus)* bugs were present in small numbers. Leafhoppers were less abundant than in previous years. The potato flea beetle, *Epitrix cucumeris* (Harr.), caused light damage to sunflowers on experimental plots at Winnipeg; this was the first record of such damage.

THRIPS.—In Alberta, *Anaphothrips obscurus* (Müll.) was present on grain at Spirit River. In Saskatchewan, *Haplothrips niger* (Osb.) was again common, but in small numbers, on red clover in northern areas; no evidence of economic damage was observed.

In Manitoba, several reports were received from Rivers, Altamont, Bede, and other points concerning thrips on barley and rye. Damage to the flag leaf sheath resulted from heat and thrips combined. In Quebec, *Limothrips cerealum* Hal. and *A. obscurus* were fairly abundant on barley heads in the Ste. Anne de la Pocatiere area.

TOBACCO INSECTS.—In southwestern Ontario, the tobacco hornworm, *Phlegethontius sextus* (Johan.), occurred in approximately the same areas as in 1954, with a more even distribution. Up to ten per cent of the tobacco plants were damaged in untreated fields early in July. Second-generation larvae were not as numerous as they had been in 1954. The tomato hornworm, *P. quinquemaculatus* (Haw.), was more generally distributed than in 1954 and the percentage of infested plants in early July varied from five to 30. Second-generation populations were small. Most fields were treated with a soil insecticide or a poisoned bait and very little damage was evident. Burley tobacco near Highgate, Kent County, had five to ten per cent of the plants damaged in untreated fields. No heavy infestations of the green peach aphid were observed.

WHEAT MIDGE.—In British Columbia, the wheat midge, *Sitodiplosis mosellana* (Gehin), cause ddamage to spring wheat in the Revelstoke, Grindrod, Enderby, and Salmon Arm districts; about 50 per cent of the wheat on one farm in the Revelstoke district was infested. In Manitoba, the midge was reported from several districts in the Red River Valley: Winnipeg, Teulon, St. Francois Xavier, St. Pierre, Transcona, and Selkirk. A few fields may have been seriously injured but, generally, the infestation was considered to have caused little commercial damage. The insect was first reported in the Province in 1954.

WHEAT STEM MAGGOT.—In northern Alberta, oats and brome grass were injured, apparently by *Meromyza americana* Fitch, at Drumheller and Sedgewick. A single report in Saskatchewan was received from Climax and, in Manitoba, small numbers were reported.

WHEAT STEM SAWFLIES..—In Alberta, wheat was severely infested by *Cephus cinctus* Nort. in many areas, but losses were believed to have been light because of the dense stand. In Saskatchewan, the infestation was markedly less than in 1954. This was particularly true in central Saskatchewan. This reduction was probably the result of severe stem rust, excessive rainfall in 1954, and heavy parasitism. Infestation in Manitoba was very light. In Ontario, *C. pygmaeus* (L). was more abundant in test plots at Guelph than at any other time in the last 12 years. It was estimated that 20 per cent of the stems of some varieties were infested. In southwestern Ontario, average numbers were reported, marginal cutting of one to five per cent being common.

VEGETABLE INSECTS

APHIDS.—Populations of aphids on vegetable crops on Vancouver Island, B.C., remained generally small. On the lower mainland of the Province, however, control measures were necessary against the pea aphid, *Macrosiphum pisi* (Harris), on peas; the cabbage aphid, *Brevicoryne brassicae* (L.), on broccoli and brussels sprouts; and *Cavariella patinacae* (L.) on celery. *Aphis rumicis* (L.) and the green peach aphid, *Myzus persicae* (Sulz.), were again present in large numbers on pole beans in the Kelowna district, causing at least 50 per cent reduction in the

canning crop, but no disease developed. Aphids were not so noticeable on potatoes in the interior as they were in 1954, but there was evidence of leaf roll virus in many fields. In Saskatchewan, aphids were more widespread and abundant than for several years on a large variety of vegetables. The pea aphid and the cabbage aphid were abundant on brussels sprouts at Saskatoon and moderate to severe infestations of the latter also occurred on cabbage, cauliflower, and rutabagas. The turnip aphid, *Rhopalosiphum pseudobrassicae* (Davis), was abundant on turnips at Humboldt. At Saskatoon *Macrosiphum solanifolii* (Ashm.) occurred on lettuce and one carrot was heavily infested at the crown below soil level with *Aphis tulipae* B. de F., a species not previously reported. Dandelions were heavily infested in some instances with *Macrosiphum taraxaci* (Kalt.). The sugar-beet root aphid, *Pemphigus betae* Doane (=*P. balsamifera* Williams), was present in most of southern Alberta, but populations appeared to be smaller than normal because of predators. In Manitoba, aphids were numerous on late cabbage and rhubarb, but were scarce on potatoes. The turnip aphid was numerous in south-central Ontario, but damage was minor. In southwestern Ontario, infestations of the potato aphid on tomatoes in Kent County were among the most severe in memory and moderate infestations of the melon aphid, *Aphis gossypii* Glov., developed on cucumbers in kitchen gardens. In the Chatham area the cabbage aphid was less numerous than usual on crucifers, but on Walpole Island a serious infestation rendered unmarketable five acres of brussels sprouts. In eastern Ontario, the species was more abundant than for several years on cole crops generally. In Quebec, aphid populations were of no economic importance. In New Brunswick and Nova Scotia, potato-infesting aphids, notably *Myzus persicae* (Sulz.) and *Phis abbreviata* Patch, were more numerous than in 1954. In Prince Edward Island *Macrosiphum solanifoliae* (Ashm.) became very numerous on potatoes in some areas, but other species were not important. No serious numbers occurred in Newfoundland.

ASPARAGUS BEETLES.—In Manitoba, *Crioceris duodecimpunctata* (L.) caused little damage in the Winnipeg area and was not observed in the western part of the Province. In Ontario, this species occurred in moderate numbers on late cuttings of asparagus. *C. asparagi* (L.) appeared in the lightest infestation in many years in southwestern Ontario and was scarce in eastern counties.

CATTERPILLARS ON CABBAGE.— In British Columbia, control measures were necesary for the imported cabbageworm, *Pieris rapae* (L.), for the first time in several years on Vancouver Island, and in the interior the insect was unusually abundant in the Kelowna and Williams Lake areas. Severe infestations were reported from the Barnwell and Lethbridge districts in Alberta. In Saskatchewan, adults were generally distributed and very numerous, but damage was no more severe than in 1954, when defoliation ranged from 40 to 80 per cent. In Manitoba, considerable mid-season damage occurred and large flights of adults were observed in southern areas. In Ontario, adults appeared in incredible numbers in southwestern counties; severe larval infestations developed in late July and continued into September. Heavy infestations were reported in south-central Ontario and about average numbers in eastern and southwestern Quebec. Normal abundance was reported in New Brunswick and Nova Scotia. Large populations developed in Prince Edward Island, causing extensive damage to turnips, and in Newfoundland distribution was general but damage light.

The cabbage looper, *Trichoplusia ni brassicae* (Riley), remained scarce in Manitoba. In Ontario, however, outbreaks in southwestern and eastern counties were among the most severe on record; near normal numbers were reported in south-central districts. Numbers in the Ottawa Valley were four times normal. In Quebec, moderate to severe damage was reported from the Chateauguay Basin, and in the St. Lawrence Gulf area little damage occurred.

The diamondback moth, *Plutella maculipennis* (Curt.) was unusually abundant on crucifers on Vancouver Island, B.C. In Manitoba, slightly reduced infestations caused negligible damage. In Ontario, populations were larger than those of 1954 in southwestern and eastern counties. Records in the Ottawa Valley indicated numbers to be 50 per cent above those of an average year. Little damage was reported in the St. Lawrence Gulf provinces, excepting Kings County, N.S., where several plantings of cabbage and turnips were severely injured.

CARROT RUST FLY.— In southwestern British Columbia light infestations of first-generation larvae of *Psila rosae* (F.) caused some damage to carrots in gardens. No late-season damage was reported in the Victoria area, but at Chilliwack 80 per cent infestation in untreated plots was recorded. In the interior, infestation was the lightest in five years and injury minor. In Ontario, too, greatly reduced numbers were reported, especially in the Holland Marsh, where extensive floods in October, 1954, destroyed a large percentage of the larvae and pupae. In Quebec, some increase was noted at Ste. Anne de la Pocatiere. In the St. Lawrence Gulf provinces, damage was generally light in commercial plantings, but some severe damage occurred in gardens, and in the Maugerville-Sheffield area of New Brunswick parsnips were more severely injured than carrots.

COLORADO POTATO BEETLE.— Infestations in the east and west Kootenays, B.C., were generally light. In Alberta, damage occurred mainly in small gardens. In Saskatchewan, from Regina southward, a gradual increase was noted for the third successive year, but damage

was light. In Manitoba, too, some increase and minor losses were reported. In Ontario, populations were generally small to medium. Tomatoes were lightly attacked at Chatham, Ont., and at Ottawa an unusually late appearance of larvae, probably of the second generation, was observed on August 24. In Quebec, increased numbers were indicated in eastern townships and moderate abundance in southwestern areas. Normal numbers and minor damage were reported in New Brunswick and Prince Edward Island, but in Nova Scotia some increase was noted and severe infestations occurred in Pictou County, including Caribou Island.

CUCUMBER BEETLES.—The striped cucumber beetle, *Acalymma vittata* (F.), was scarce in Quebec and less numerous than in 1954 in New Brunswick, causing little damage. In Nova Scotia it was unusually numerous on squash at Berwick, Kings County.

FLEA BEETLES.—The potato flea beetle, *Epitrix cucumeris* (Harr.), occurred at Estevan, Sask., in the largest numbers in seven years, severely injuring potato foliage, but elsewhere in the Province it was of minor importance. In Manitoba it damaged small tomato transplants severely at Brandon, Pipestone, Lyleton, andBoissevain. A moderate infestation occurred in large fields of potatoes at Carman, Morden, and Dauphin. In Ontario, infestation was widespread and potatoes in kitchen gardens were, as usual, extensively injured. In Quebec, the species was abundant in many tomato, potato, and bean crops in the St. Gregoire and St. Jean districts, but no severe injury was noted in eastern districts. In New Brunswick, severe injury occurred in Carleton and Victoria counties. In Nova Scotia, Prince Edward Island, and Newfoundland, moderate numbers and no serious injury were reported. The tuber flea beetle, *Epitrix tuberis* Gent., caused less damage than usual in southwestern British Columbia, but in the Kamloops and Vernon areas potatoes were severely damaged where control measures were not applied. Tomato seedlings, too, were attacked and growth was retarded. At Armstrong, B.C., the insect fed on carrot foliage following the destruction of potato vines by frost. This apparently constitutes a new host record. *Phyllotreta albionica* (Lec.) required control measures on cruciferous transplants and seedlings in southwestern British Columbia. *Phyllotreta striolata* (F.) occurred on crucifers in moderate numbers in Manitoba, but in southwestern Ontario caused 100 per cent loss of radish in some gardens and seriously damaged other crucifers. In the Ottawa Valley, *Phyllotreta,* sp. severely injured turnip and cabbage. In southwestern Quebec, *Systena frontalis* (F.) injured the foliage of wax beans.

GREEN CLOVERWORM.— The most severe outbreak of *Plathypena scabra* (F.) since 1931 extensively injured the foliage of soybeans and white beans in Kent County, Ont., but losses were light.

LEAFHOPPERS.— In Manitoba, the potato leafhopper, *Empoasca fabae* (Harr.), caused extensive hopperburn on potatoes in the Winnipeg, Morden and Brandon areas. In southwestern Ontario, widespread infestations occurred on potatoes, white beans, lima beans, and soybeans. Extensive infestations occurred also in Quebec and New Brunswick, but in Newfoundland numbers were small. In Manitoba, the *Macrosteles fascifrons* (Stal) complex caused a great deal of aster yellows in head lettuce and carrots in the Winnipeg, Morden and Brandon areas. In Ontario, the species was numerous on these hosts in the Holland Marsh.

LEAF MINERS.— In Saskatchewan, the spinch leaf miner, *Pegomya hyoscyami* (Panz.), damaged swiss chard, spinach, and beet greens at Melfort and Melville; at Regina, damage was only half as heavy as in 1954. In Manitoba little damage was reported. In southwestern Ontario, red beets, sugar beets, and spinach were commonly infested, but damage was slight. In south-central Ontario, infestations assumed outbreak proportions and some severe local injury to beets resulted in the Holland Marsh.

MAGGOTS IN ONIONS|— In British Columbia the onion maggot, *Hylemya antiqua* (Mg.), caused severe damage to onions from Grand Forks to Kamloops and also in the Quesnel district. In Saskatchewan, mortality of 15 to 20 per cent in onions on truck farms and one to ten per cent in dry-land gardens was considerably less than in 1954. In Manitoba infestation was light at Morden, but increased slightly at Winnipeg. In southwestern Ontario, damage to silverskins, onions grown for sets, and cooking onions ranged from a trace to approximately 25 per cent in the Erie Beach, Dover, Thedford, and Grand Bend marshes. Damage in south-central Ontario was the most severe in several years in many muck-soil areas, but was average in the Holland Marsh. In southwestern Quebec, damage ranged from 30 to 60 per cent in the Montreal area and in eastern Quebec was above average. In New Brunswick, extensive losses occurred in small gardens in the Fredericton area.

MEADOW SPITTLEBUG.— In Ontario an unusual infestation of *Philaenus leucophthalmus* (L.) occurred in head lettuce and spinach in the Thedford-Grand Bend vegetable-growing area. Approximately 50 per cent of a two-acre field of spinach and 80 per cent of a two-acre field of head lettuce were destroyed.

MEXICAN BEAN BEETLE.— In Ontario, *Epilachna varivestis* Muls. was abundant on wax beans in light-soil areas about Niagara Falls. In Quebec, very small numbers were observed near St. Hilaire.

MITES.—In British Columbia, *Petrobia latens* (Müll.), commonly called the brown wheat mite, caused considerable injury to the leaves of onions near Kelowna during August. The species had not previously been recorded on onions in British Columbia and apparently not in Canada. In Ontario, infestations of the tomato russet mite, *Vasates destructor* (Keif.), were less extensive than in 1954 on the tomato canning crop.

PLANT BUGS.—In British Columbia, populations of *Orthops* (=*Lygus*) *scutellatus* Uhl., which had been at a low ebb for several years following serious outbreaks on carrot-seed crops in the Grand Forks district in 1947 and 1948, increased noticeably. The heaviest infestation occurred in the southeastern part of the district, where one field had 203 bugs per 50 green seed umbels. Heavy infestations occurred also on wild umbelliferous plants in the Kamloops and Falkland districts. In eastern Ontario, populations of *Licocoris* (=*Lygus*) *lineolaris* (Beauv.) were larger on vegetable crops than in any other year since 1952. Large populations and considerable injury to potato, celery, and other plants occurred in Quebec. Reduced numbers were noted in Nova Scotia.

POTATO STEM BORER.— In Quebec, *Hydroecia micacea* (Esp.) was present in garden corn and potatoes in the Levis to Rimouski area. In New Brunswick a severe attack was reported from Coverdale. In Nova Scotia, potatoes were damaged in Lunenburg County, corn in Kings, Hants, and Digby counties, and rhubarb in Hants and Halifax counties. In Newfoundland, damage in gardens was negligible.

ROOT MAGGOTS IN CRUCIFERS.— First-generation larvae of the cabbage maggot, *Hylemya brassicae* (Bouché), caused the greatest damage in ten years at Victoria, B.C., up to 90 per cent mortality of cabbage being reported. Later generations severely damaged rutabagas, especially on the lower mainland and in the interior of the Province. In Alberta, damage to rutabagas was especially serious in the Lethbridge Northern Irrigation Project area; several fields were not harvested and in many others damage ranged from 20 to 50 per cent. The area around Lethbridge and Taber suffered only minor losses. In Ontario generally, excepting a few locally severe infestations, crucifers were less severely attacked than in most years. In study plots at Ottawa, the percentage mortality in untreated cabbage ranged from 21 to 64. In southeastern Quebec, damage to cabbage and radish was well above average. In New Brunswick, approximately 15 per cent damage occurred in early cabbage and cauliflower, but the late crop was almost entirely free of attack. Normal abundance was indicated on most crops in Nova Scotia and on turnips in Prince Edward Island. Infestation was fairly heavy in Newfoundland. In Saskatchewan, the turnip maggot, *Hylemya floralis* (Fall.), was slightly less numerous than in 1954 in dry-land gardens. In truck farms 20 to 30 per cent of untreated cabbage and cauliflower were killed and 60 to 70 per cent of untreated rutabagas damaged. In Manitoba, populations were very small and damage was light. *Hylemya planipalpis* (Stein.) caused minor damage to radish in Saskatchewan and Manitoba.

SEED-CORN MAGGOT.— *Hylemya cilicrura* (Rond.) was not recorded in British Columbia. In Manitoba no damage was reported from Winnipeg, but at Brandon adults emerged freely from a field in which turnips had grown in 1954 and one farmer reported total loss of peas. As usual in southwestern Ontario, the seed-corn maggot was a serious pest in field beans and, to a lesser extent, in soybeans. Numerous fields of beans were re-seeded in Kent Country. A peculiar feature of some of the infestations was the occurrence of maggots in the seedling stems. This had not been observed in previous years in beans, although it occurred in cucumbers in 1954. Infestations also developed in peas, oats, and barley in experimental plots. Potato seed pieces were lightly infested in Harwich Township, Kent County. In the Leamington and Burlington areas, large losses resulted from maggots in the heads of cauliflower. In eastern Quebec, light infestations were observed on beans. Little damage occurred in New Brunswick. A few fields of beans were severely damaged in Kings County, N.S., but elsewhere in the Province infestations were lighter than in 1954. In Prince Edward Island, minor damage was done to beans and cucumbers.

SLUGS.— In British Columbia, slugs were more troublesome than usual. In the Chilliwack area, a grey garden slug, *Arion circumscriptus* (Johnston), and a brown slug, *Derocerus reticulatum* (Mull.) caused severe losses in corn and bean seedlings, and in one instance reduced the stand in a potato crop by feeding on the seed pieces. Another slug, probably *Arion ater* (L.), was present in epidemic numbers at Hope and at Popcum and no garden crops of any kind could be grown because of its voracious feeding. Destructive populations were noted also in central regions and the Okanagan district. In Saskatchewan, where slug injury is rare, potatoes, beans, tomatoes, and peas were damaged at Lanigan. At Winnipeg, Man., reports of damage to garden crops by *D. reticulatum* have increased annually. In an unusual spring infestation in Kent County, Ont., the leaves of corn were severely shredded, and throughout the Province slugs continued to be a major pest of garden crops. In Quebec, too, damage was widespread and in New Brunswick considerable losses occurred in the Fredericton area.

SPINACH CARRION BEETLE. — In Alberta, *Silpha bituberosa* Lec. and flea beetles combined to cause severe damage to 4,000-5,000 acres of sugar beets before control materials were applied.

SQUASH BUG.— In Ontario, infestations of *Anasa tristis* (Deg.) on pumpkin and squash in Kent and Essex counties were very light.

SQUASH VINE BORER.—At Chatham, Ont., adults of *Melittia cucurbitae* (Harr.) appeared much earlier than usual and the larvae destroyed many plants of squash and pumpkin in kitchen gardens.

SUGAR BEET-INFESTING ROOT MAGGOT.— In Alberta, a root maggot, *Eurycephalomyia myopaeformis* (Roed.), seriously damaged sugar beets in light soil areas about Cranford and Taber. Damage was reported also in Manitoba, especially in the Steinbach area.

SUGAR-BEET WEBWORM.— Infestations of *Loxostege sticticalis* (L.) in Alberta were the most severe and general since 1946. Control measures were necessary against the first generation throughout beet-growing districts.

THRIPS.— In southwestern Ontario, the onion thrips, *Thrips tabaci* Lind., occurred in moderate infestations in Kent and Essex counties on Spanish, cooking, silverskin, and set onions and on field beans, lima beans, and soybeans.

TOMATO HORNWORM. —Populations of *Phlegethontius quinquemaculatus* (Haw.) on tomato varied greatly in Ontario. In Hastings County, it was very common at Tweed but scare in other areas. In New Brunswick, a few specimens were observed in the Maugerville area.

FRUIT INSECTS

APHIDS.— *Aphis pomi Deg.* was numerous on apple and difficult to control in British Columbia, Ontario, and Quebec. In New Brunswick and Nova Scotia, it was less numerous and caused little damage. *Anuraphis roseus* Baker was of little economic importance except in Nova Scotia, and even there caused only moderate damage. *Rhopalosiphum prunifoliae* (Fitch) was abundant in Ontario and caused unusual curling of apple foliage. In Nova Scotia it was moderately abundant. *Eriosoma lanigerum* (Hausm.) was present in scattered, light infestations in Quebec and Nova Scotia. *Hyalopterus arundinis* (F.) was troublesome, especially on apricots, in British Columbia and was abundant in Essex County, Ont. *Myzus cerasi* (F.), although less injurious than in 1954, was still the most important pest of cherries in the interior of British Columbia. In Ontario, it was a minor problem in most orchards. *Myzus persicae* (Sulz.) was less numerous than in 1954 in British Columbia and no severe infestations were reported, but *Anuraphis cardui* (L.) was again injurious to plum and prune. In southern Manitoba, *Capitophorus ribis* (L.) severely infested red and white currants. In southwestern British Columbia, *Capitophorus fragaefolii* (Ckll.) was numerous but of minor importance on strawberry, and some plantings were severely attacked by *Myzus ascalonicus* Doncaster. In New Brunswick, a few infestations of *Capitophorus minor* (Forbes) and *C. fragaefolii* were noted on strawberry.

APPLE (AND BLUEBERRY) MAGGOT. — In Manitoba *Rhagoletis pomonella* (Walsh) was much less abundant than in 1954 and even scarce. In Ontario and Quebec the number of infested apple orchards and the degree of infestation were lower than in 1954. In the Niagara Peninsula, Ont., severe infestations persisted in a few prune orchards. In New Brunswick, ten apple orchards, out of 20 inspected, were lightly infested. In Nova Scotia, infestation in commercial orchards was generally light. Severe damage occurred in unsprayed orchards in Prince Edward Island, but populations were normal. Infestation of blueberries by this insect declined sharply in New Brunswick for the second year and no rejections at canning plants were reported. Infestation of blueberries in Prince Edward Island ranged from zero to five per cent and in Newfoundland the crop was free of damage.

APPLE MEALYBUG.—*Phenacoccus aceris* (Sign) persisted as a minor pest of apple in New Brunswick and Nova Scotia.

APPLE SUCKER.— In Nova Scotia most infestations of *Psylla mali* (Schmbd.) were light to medium, but a few were fairly severe.

CHERRY FRUIT FLIES. — In British Columbia, *Rhagoletis cingulata* (Loew) severely infested sour cherries in southern Vancouver Island, and, in the interior, an orchard at Abbotsford also was heavily infested. Cherries in the latter area previously had been relatively free of attack. For the first time in many years *R. fausta* (O.S.) attacked sweet cherries near Creston.

CODLING MOTH.— In the Okanagan Valley, B.C., *Carpocapsa pomonella* (L.) was rather more injurious than in 1954. In Ontario it was increasingly difficult to control in all areas except in Essex County. The first brood caused little damage, but the second brood was very injurious in many apple and pear orchards. On southwestern Quebec, it was the most destructive pest of apple; as in Ontario, unusually warm weather resulted in a very large second brood. Injury in some orchards in the Franklin and Chateauguay districts ranged from 25 to 40 per cent of the crop. In eastern Quebec populations remained small. In New Brunswick infestations were lighter than in 1954 and control was rarely necessary. In Nova Scotia, the percentage of apples infested was small.

CRANBERRY FRUITWORM.— Populations of *Mineola vaccinii* (Riley) persisted at a high level in most wild and a few commercial cranberry bogs in New Brunswick. Normal numbers were reported in Prince Edward Island.

CURCULIONIDS.— A light infestation of *Conotrachelus nenuphar* (Hbst.) occurred at Morden, Man. In Ontario, infesation was lighter than in 1954 in the Niagara Peninsula and Norfolk County. In the latter area, injury to apples was light. In Essex County serious injury was reported on apple, peach, plum and apricot only where adequate control measures were not aaken. In Quebec, infestations were rather light in the southwestern area and normal in the southeast. In Nova Scotia, control measures were necessary in a few orchards. In southwestern British Columbia, untreated strawberry plantings were heavily infested with larvae of *Brachyrhinus sulcatus* (F.). A minor infestation occurred at Bay Roberts, Nfld. In the Keating area on Vancouver Island, B.C., strawberry plantings were severely attacked by *Sciopithes obscurus* Horn. In the St. Lawrence Gulf provinces *Anthonomus signatus* Say caused only minor damage to strawberry and raspberry. *Brachyrhinus ovatus* (L.) was a minor pest of strawberry in Manitoba, and although the insect was commonly reported in Eastern Canada as a household pest, field damage was, in general, comparatively light.

CURRANT FRUIT FLY.—In Saskatchewan *Epochra canadensis* Loew was again reported only from the area south of Saskatoon and appeared to be declining. In southern Manitoba it appeared in its usual numbers and losses were heavy in untreated plantings.

EYE-SPOTTED BUD MOTH.— In British Columbia, *Spilonota ocellana* (D. & S.) was somewhat more troublesome on apple than in 1954, especially in the Okanagan Valley. in Ontario it was, in general, of little importance, excepting a few severe local infestations in neglected orchards. In Quebec, infestation was general and considerable damage occurred in the Rougemont and St. Hilaire districts. Little damage was done in New Brunswick. In Nova Scotia, after several years' decline, the population level, with a few local exceptions, remained at the low point reached in 1954, the lowest in several decades; parasitism of over-wintering larvae by *Agathis laticinctus* (Cress.) amounted to about 40 per cent. In Prince Edward Island, damage was extensive in untreated orchards.

FLEA BEETLES.— A large infestation of *Altica woodsi* Isely damaged leaf and flower buds of grape at Morden, Man. In southern Ontario, *Altica chalybea* (Ill.) was of little importance, after two years of heavy infestation.

FRUIT TREE BORERS.—The roundheaded apple tree borer, *Saperda candida* F., occurred in reduced numbers in Quebec and was a minor pest in New Brunswick. In British Columbia the peach twig borer, *Anarsia lineatella* Zell., and the peach tree borer, *Sanninoidea exitiosa exitiosa* (Say) remained minor pests, although the latter caused moderate injury to peach, apricot, and prune in neglected orchards. In Ontario its status remained unchanged and the lesser peach tree borer, *Synanthedon pictipes* (G. & R.), continued to be a serious pest of peach in Essex County; it was less serious in the Niagara area.

GRAPE BERRY MOTH. — In the Niagara Peninsula, Ont., *Polychrosis viteana* (Clem.) continued to increase and severe infestations occurred in the Beamsville, St. Davids and Virgil areas. An increase was noted also in Essex County.

GREEN FRUITWORMS.— Minor infestations of the fall cankerworm, *Alsophila pometaria* (Harr.), occurred at Morden and Dauphin, Man. In Nova Scotia it was troublesome in King County. This species and the spring cankerworm, *Paleacrita vernata* (Peck), continued to be very scarce in Ontario and Quebec orchards. In Nova Scotia, populations of *Lithophane* spp. and *Xylena* spp. continued to decline for the second year; *Hedia variegana* (Hbn.) remained scarce as in previous years; and the winter moth, *Operophtera brumata* (L.), became established in the Annapolis Valley; at Grand Pré it completely defoliated one orchard.

IMPORTED CURRANTWORM.— In Western Canada, *Nematus ribesii* (Scop.) was numerous at Cranbrook, B.C., and occurred in light infestations at Saskatoon, Sask., and Brandon, Man. In the east it was very abundant in eastern Quebec, seriously defoliated black currant in Colchester County, N.S., damaged gooseberry in some areas of Prince Edward Island, and caused minor losses in Newfoundland.

LEAFHOPPERS.— In southwestern British Columbia, *Macropsis fuscula* (Zett.), first observed infesting loganberries on Lulu Island in 1952, was found for the first time on this host in the Keating area of southern Vancouver Island. Five commercial plantings were moderately infested. Populations continued to be high in commercial loganberry plantings on Lulu Island. There has been no report of the occurrence of rubus stunt virus, which is transmitted by this leafhopper in Europe. The second generation of the bramble leafhopper, *Ribautiana tenerrima* (H.-S.), was very abundant and large numbers of adults were observed ovipositing in new canes. The rose leafhopper, *Edwardsiana* (=*Typhlocyba*) *rosae* (L.), was found in conjunction with all *R. tenerrima* populations and in many cases was abundant. In the interior the buffalo treehopper, *Stictocephala bubalus* (F.), continued to be troublesome in some newly planted orchards in northern districts of the Okanagan Valley. In Manitoba a severe infestation of the potato leafhopper, *Empoasca fabae* (Harr.), developed on apples. Its appearance coincided with a severe outbreak of fireblight. In southern Ontario, grape leafhoppers, *Erythroneura* spp., had practically disappeared where DDT had been used annually. In southwestern Quebec, *S. bubalus, S. inermis* (F.), and *Ceresa diceros* (Say) caused damage in isolated young orchards at Frelighsburg. In eastern Quebec, *Empoasca maligna* (Walsh) was scarcer than in 1954. In Nova Scotia *Typhlocyba pomaria* McA. was moderately numerous in a few orchards.

LEAF ROLLERS.— *Archips argyrospila* (Wlkr.) remained of minor importance on fruit trees in British Columbia, but continued to increase in southwestern Quebec, causing light damage. As a result of unusual weather conditions, a third brood of the red-banded leaf roller, *Argyrotaenia velutinana* (Wlkr.), appeared in southern areas of Ontario and Quebec. Injury was slightly greater than usual but rarely serious. In Nova Scotia, the gray-banded leaf roller, *Argyrotaenia mariana* (Fern.), was generally present in small numbers, excepting a few moderate to heavy infestations in central Kings County; fruit injury was moderately light. Other species of leaf rollers were generally present in small numbers, but damage to fruit was relatively light. On strawberry, *Exartema olivaceanum* (Fern.) was numerous at Keating, B.C., and an undetermined leaf roller appeared in large numbers at Dunleath and Conquest, Sask., causing some severe damage. Moderate to severe infestations of *Ancylis comptana fragariae* (W. & R.) occurred again on strawberry in southern Ontario.

MITES.— In British Columbia, the European red mite, *Metatetranychus ulmi* (Koch), was more noticeable on all varieties of tree fruits than in 1954, apparently developing strains resistant to organic phosphates. In Ontario it was more abundant on apple than in 1954 in most areas and was also somewhat more abundant than for several years on peach and plum in the Niagara Peninsula; it was less troublesome in Essex County. It continued to be an important orchard pest in Quebec and New Brunswick, requiring control treatment in many orchards; a general increase was reported in New Brunswick. In Nova Scotia, little injury occurred on apple, but in Prince Edward Island damage was severe in some orchards. In British Columbia, *Tetranychus bimaculatus* Harvey heavily infested strawberry on southern Vancouver Island and in the interior caused considerable late-season injury to the foliage of apple. In Ontario, a general increase in abundance on apple and peach was reported from all fruit-growing areas, but injury was usually not serious. In southwestern Quebec this mite occurred in outbreak proportions on apple for the first time on record, partly as a result of weather conditions. In Ontario, *Septanychus* sp. continued to be abundant in a few apple orchards in the Burlington-Vineland area. *Eriophyes pyri* (Pgst.) was more injurious than in 1954 in British Columbia. In a survey of plant nurseries in the Niagara Peninsula, Ont., this mite was found in nearly all establishments. In Quebec, several orchards at Frelighsburg were infested. In Nova Scotia the mite decreased somewhat on apple but the usual numbers developed on pear. In Prince Edward Island some serious injury to pear was reported. In the interior of British Columbia, *Eriophyes* spp., present in the greatest numbers in several years and the most troublesome of all mite species, caused considerable injury to apple, peach, prune, and cherry. *Vasates schlectendali* (Nal.) also was very common on apple. In Manitoba, *Eriophyes* spp. caused some severe russetting of plum and apple foliage. The clover mite, *Bryobia praetiosa* Koch, occurred on fruit trees in reduced numbers in British Columbia and was of minor importance in Ontario, although serious injury in one orchard in Norfolk County was the first record of injury to apples in the area. In Nova Scotia the species required control measures in some orchards. In the interior of British Columbia *Eotetranychus pacificus* (McG.) occurred in the greatest abundance since 1950 and in southern Manitoba this species and *E. mcdanieli* (McG.) developed large populations on raspberry. *Eotetranychus carpini borealis* (Ewing) was less injurious than in 1954 in British Columbia and *Tarsonemus pallidus* Banks was less numerous on strawberry in Manitoba. No mite infestations were reported in Saskatchewan.

NEMATODES.— In New Brunswick various species of nematodes were found in association with root rot of strawberry in the Washademoak and Grand Lake areas and elsewhere.

ORIENTAL FRUIT MOTH.— Infestation by *Grapholitha molesta* (Busck) in Ontario was at first generally light and parasitism was high, but there was a gradual increase in infestation in succeeding generations. Control measures held fruit injury at a low level in the Niagara

Peninsula, but in Essex County more extensive controls were needed. For the second time in 10 years, Kieffer pears were seriously injured. A survey of young nursery stock in the Niagara district revealed some infestation in cherry and plum as well as peach.

PEAR PSYLLA.—In British Columbia, threatening early infestations of *Psylla pyricola* Foerst. were reduced by hot weather. In Ontario, unusually heavy infestations, requiring special control measures, developed in June in the Niagara Peninsula and the Burlington-Oakville area, but numbers were greatly diminished by autumn. Damage was light in Essex County.

PEAR-SLUGS. — In British Columbia both *Pristophora californica* (Marl.) and *Caliroa cerasi* (L.) were minor pests. In Manitoba no damage was reported. In Ontario, *C. cerasi* severely damaged many young neglected orchards in Essex County, but was of little importance elsewhere. A survey of nursery stock in the Niagara Peninsula revealed infestations on pear, cherry, howthorn, apple, plum, quince, and mountain ash. No infestations were reported in Quebec; cherry was commonly attacked in Prince Edward Island; and minor numbers were noted in Newfoundland.

PLANT BUGS.— In British Columbia, plant bugs continued to be unimportant. In the Red River Valley, Man., *Liocoris (=Lygus) lineolaris* (Beauv.) severely attacked strawberry. In Ontario, "catfacing" of peach was less severe than in 1954 and apples were injured in a few orchards in Norfolk County. In Nova Scotia, there were only light infestations of *Neolygus communis novascotiensis* Kngt. in a few apple orchards. *Campylomma verbasci* (Meyer) was general but caused very little fruit injury. *Criocoris saliens* (Reuter), which is known to prey on phytophagous mites and some insect pests, caused an injury on apples similar to that caused by *C. verbasci;* the injury was usually slight.

RASPBERRY BUD MOTH.—In New Brunswick, *Lampronia rubiella* (Bjerk.) was found in all raspberry plantings inspected. The heaviest infestations occurred in the Fredericton and Belleisle areas. A general increase in numbers was indicated in the Saint John River Valley.

RASPBERRY CANE BORES.— *Oberea* spp. were mainly in the late larval stages and caused little ringing of raspberry and blackberry canes in eastern Ontario. In New Brunswick and Nova Scotia, as in 1954, only a few reports of injury were received.

RASPBERRY FRUITWORMS.— In Saskatchewan, *Byturus* sp. caused less damage than in 1954, being reported only from Regina and Esk. In Manitoba it occurred at Elkhorn and Manson.

RASPBERRY ROOT BORER.— In British Columbia, *Bembecia marginata* (Harr.) appeared to be on the increase on southern Vancouver Island and was found attacking commercial loganberry plantings, especially thornless loganberry.

RASPBERRY SAWFLY.— *Monophadnoides geniculatus* (Htg.) was not reported in Saswatchewan. In Manitoba a light infestation occurred at Morden and in eastern Ontario it was common and injurious to wild and cultivated raspberrries in Hastings County.

SCALE INSECTS.— In British Columbia, *Lepidosaphes ulmi* (L.) was more evident than in 1954 in some orchards. In Ontario, although plentiful on some hosts, it had not been an important pest of fruit trees for several years. In New Brunswick, too, it was reported as a minor orchard pest. In British Columbia, *Aspidiotus perniciosus* Comst. was not a pest in commercial orchards. In Manitoba it occurred on apple and plum at Morden, destroying several plum trees. In Ontario small numbers developed in several apple orchards and, near Waterford, Norfolk County, one orchard was seriously infested. A survey of nurseries in the Niagara Peninsula revealed varying infestations of this scale and *Aspidiotus ostreaeformis* Curt. on apple, flowering crab, peach, flowering plum, mountain ash, and cotoneaster. *A. ostreaeformis* was not important in British Columbia, but in Ontario it caused injury in several plum orchards. It appeared to be increasing on peach and plum in the Niagara Peninsula and moderate to severe infestations occurred in Essex County. In British Columbia, *Pulvinaria* sp. was more noticeable than in 1954 and *Lecanium* spp. were found in many more peach orchards than in previous years, especially at Summerland. A light infestation of *Chionaspis furfura* (Fitch) occurred on apple and pear at Morden, Man. Infestation of peach by *Pulvinaria vitis* (L.) continued light in the Niagara Peninsula, Ont.

A STRAWBERRY CHLAMISUS.— In New Brunswick, *Chlamisus fragariae* Brown was not seen in appreciable numbers on strawberry.

TENT CATERPILLARS AND WEBWORMS.— *Malacosoma* spp. were not reported as fruit pests west of Manitoba. In Manitoba, *M. lutescens* (N. & D.) occurred as usual in large numbers on choke cherry. In Eastern Canada, *Malacosoma* spp. were at a very low ebb and were not a problem in orchards excepting in Nova Scotia, where *M. americanum* (F.), although

much less abundant than in the two previous years, was still fairly numerous in the spring but declined rapidly during the summer. The webworm *Hyphantria textor* Harr. was fairly common in Norfolk County, Ont., and appeared generally in small numbers in Nova Scotia, where it had been practically absent for several years.

THRIPS.— In British Columbia, pansy spot of apple, presumably caused by *Frankliniella occidentalis* Perg., was more common in the northern areas of the Okanagan Valley than in 1954. In New Brunswick and Nova Scotia, *Frankliniella vaccinii* Morgan increased very considerably in commercial blueberry fields. Greatest damage occurred in Charlotte County, N. B., where in some sprout fields an average of 20 to 30 plants per square foot were infested.

PREDATORS OF ORCHARD PESTS.— In Nova Scotia, predators of apple pests continued to be scarce in Annapolis Valley orchards. Their numbers varied greatly, however, and in a few orchards they were abundant. In these few orchards one of the following, in order of importance, was usually the most abundant species: *Haplothrips faurei* Hood, *Anthocoris musculus* (Say), *Hyaliodes harti* Kgt., and *Anystis agilis* Banks. Predacious mites of the family Phytosiidae were found in large numbers in some orchards. *Criocoris saliens* (Reuter) was not an important predator, but was of some economic importance because of its occasional habit of stinging the fruit. There was little change in the status of such general predators as coccinellids, pentatomids, chrysopids, and spiders.

INSECTS AFFECTING GREENHOUSE AND ORNAMENTAL PLANTS

ANTS.— As usual, ants commonly infested lawns and gardens and were a nuisance on some flowering plants. A general increase, associated with hot dry weather, was noted in Ontario and Quebec.

APHIDS.— In southwestern British Columbia, aphids on ornamentals were numerous but below peak levels. At Cranbrook, B.C., *Aphis tulipae* B. de F. infested tulip bulbs. In Alberta, aphids were very abundant on ornamental flowers and shrubs. *Amphorophora crataegi* (Monell) was recorded for the first time in the Province, being found on *Crataegus* sp. in Edmonton. *Eriosoma lanigerum* (Hausm.) and *E. americanum* (Riley) were both conspicuous about Edmonton and *Cinara* spp. were reported. In Saskatoon, Sask., sweet peas were severely infested. In western Manitoba, aphids were abundant on many hosts, but in the Winnipeg area were less numerous than in 1954. The woolly elm aphid, *E. americanum,* which occurred in outbreak numbers in 1954, was much less abundant in 1955. The elm cockscomb gall, *Colopha ulmicola* (Fitch), was also less abundant. The boxelder aphid, *Periphyllus negundinis* (Thos.), was very abundant at Morden and Brandon. In Ontario and Quebec, aphids were generally abundant. At Maugerville, N.B., sweet peas were severely infested. In Newfoundland, aphids were very numerous on ornamental elm.

BOXELDER BUG.— *Leptocoris trivittatus* (Say) was abundant on boxelder at Morden, Man., and in southwestern Ontario.

CURCULINONIDS.—In southwestern British Columbia, *Brachyrhinus singularis* (L.) commonly damaged the foliage of holly in ornamental plantings. In Alberta the willow flea weevil, *Rhynchaenus rufipes* (Lec.), was recorded for the first time in the Province, when found damaging *Salix pentandra* L. in Edmonton. The rose curculio, *Rhynchites bicolor* (F.), was reported from Regina and Saskatoon, Sask., and from Brandon and Morden, Man. In Ontario, *Apion longirostre* Oliv., although less numerous than in 1954, occurred commonly on hollyhock in the Niagara Peninsula.

A CYPRESS MOTH.— Monterey cypress in the Oak Bay area of Victoria, B.C., was very severely attacked by a moth, probably *Argyresthia cupressella* Wlshm.

EUROPEAN EARWIG.— *Forficula auricularia* L. continued to be the most important insect pest of back-yard gardens in southwestern British Columbia. There does not appear to have been any general decrease in populations in spite of the efforts of some householders.

EUROPEAN PINE SHOOT MOTH.— Evidence of *Rhyacionia buoliana* (Schiff.) in varying degrees of infestation was found on Mugho and other species of pine, during a nursery survey, in at least 14 separate areas throughout the Niagara Peninsula, Ont. In Newfoundland, the insect was common on the Avalon Peninsula and appeared for the first time in western Newfoundland on Scots pine at Corner Brook.

FALL CANKERWORM.— In Manitoba, *Alsophila pometaria* (Harr.) was much reduced in numbers in the Winnipeg area but was much more abundant than in 1954 in the Brandon area, where considerable defoliation of shade trees occurred. A spotty infestation occurred throughout southern Manitoba on windbreaks and shade trees.

GENISTA CATERPILLAR.— Found for the first time in the Niagara Peninsula in 1954, *Tholeria reversalis* (Gn.) was found in medium infestations on laburnum trees at opposite ends of the Peninsula: near Niagara Falls and at Stoney Creek.

HOLLY BUD MOTH.— *Rhopobota naevana* (Hbn.) was very abundant on all unsprayed holly in southwestern British Columbia. New growth on many trees was 100 per cent infested.

LEAF BEETLES.—A willow leaf beetle, *Galerucella decora* (Say), caused considerable defoliation of willow throughout western Manitoba. In southern Ontario, the elm leaf beetle, *Galerucella xanthomelaena* (Schr.), built up to an alarming extent, especially in the residential areas of Stamford, Niagara Falls, and Chippawa in Welland County. It was also abundant in commercial nurseries in the Niagara-on-the-Lake and St. Catharines areas of Lincoln County and in the Fonthill and Fenwick areas of Welland County. In southwestern Quebec, it was observed in reduced infestations in the Lacolle, Napierville, and St. Jean areas. In Ontario, the imported willow leaf beetle, *Plagiodera versicolora* (Laich.), abundant in the vicinity of Niagara Falls for some years, was found during a nursery survey at Fonthill, St. Catharines, and as far west as Vineland. Lgiht to moderate infestations of chrysomelids, *Nodonota* spp., were found in Welland County on a wide variety of hosts. At Iberville, Que., *Galerucella* sp. was very injurious to willow.

LEAF MINERS.— Nursery survey work in the Niagara Peninsula, Ont., revealed varying degrees of infestation by *Lithocolletis crataegella* Clem. on apple, flowering crab, and flowering plum. *Phyllocnistis populiella* Cham., seldom reported in the Niagara district, was found on both native and silver poplars in Lincoln and Welland counties. The arborvitae leaf miner, *Argyresthia thuiella* (Pack.), was very abundant throughout the southern half of Hastings County, Ont., as indicated by the condition of the foliage of white cedar. The lilac leaf miner, *Gracillaria syringella* (F.), was common in most of Eastern Canada.

MITES.— In British Columbia the cyclamen mite, *Tarsonemus pallidus* Banks, was an important pest of cyclamen and commonly infested African violets in greenhouses and dwellings. In southern Manitoba, heavy infestations of *Eotetranychus pacificus* (McG.) and *E. mcdanieli* (McG.) developed on many ornamentls. In Norfolk County, Ont., small numbers of *Paratetranychus ununguis* (Jac.) and immense numbers of eggs were observed locally on white spruce in Simcoe. In eastern Quebec, *Tetranychus bimaculatus* Harvey was unusually abundant on ornamental shrubs in the Ste. Anne de la Pocatiere district.

MOURNING-CLOAK BUTTERFLY.—*Nymphalis antiopa* (L.) was taken commonly on willow in Manitoba and on willow, elm, and popular in the Niagara Peninsula, Ont.

NARCISSUS BULB FLY.— Infestation of narcissus by *Lampetia equestris* (F.) in southwestern British Columbia was severe, ranging from 50 to 85 per cent in some plantings.

ORANGE TORTRIX.— In British Columbia, *Argyrotaenia citrana* (Fern.) continued to be a pest on holly in the Saanich district.

PEAR-SLUG.— *Caliroa cerasi* (L.) commonly infested cotoneaster, mountain ash, and other hosts in the Prairie Provinces.

PLANT BUGS.— The tarnished plant bug, *Liocoris* (=Lygus) *lineolaris* (Beauv.), occurred commonly on ornamentals, but no outbreaks were reported. In Manitoba, heavy infestations of *Neoborus amoenus* (Reut.) were observed on ash at Morden and near Brandon.

POTATO STEM BORER.— *Hydroecia micacea* (Esp.) damaged gladiolus in eastern Quebec.

ROSE CHAFERS.— In Alberta, *Dichelonyx backii* (Kby.) was present in large numbers on wild roses and in smaller numbers on cultivated roses, notably in the Calgary district. In the Niagara Peninsula, Ont., *Macrodactylus subspinosus* (F.) was encountered in light to heavy concentrations on apple, pear, cherry, Chinese chestnut, mountain ash, Chinese and other elms, willow, basswood, maple, sycamore, walnut, honeysuckle, privet, hydrangea, spirea, deutzia, rose, peony and asparagus.

SAWFLIES.— *Diprion hercyniae* (Htg.) occurred commonly on ornamental spruce in most provinces. In Prince Edward Island and Newfoundland *Pristiphora geniculata* (Htg.) caused extensive defoliation of mountain ash.

SATIN MOTH.—In Quebec, populations of *Stilpnotia salicis* (L.) remained at a low level. In Newfoundland poplar was defoliated at Gander, Gambo, Bishop Falls, Deer Lake, and on the Avalon Peninsula. Aspen was severely damaged at Rattling Brook.

SCALE INSECTS.– *Lepidosaphes ulmi* (L.) occurred on cotoneaster at Winnipeg, Man.; on lilac, apple, poplar, honeysuckle, willow, dogwood, ash, and hydrangea in the Niagara Peninsula, Ont.; and on *Sorbus americana* Marsh. near Fredericton, N. B. In Prince Edward Island it was prevalent on several hosts. The pine needle scale, *Phenacaspis pinifoliae* (Fitch), occurred on pine in Alberta, on spruce at Morden, Man., and on ornamental evergreens in Winnipeg, Man., *Carulaspis visci* Shrk., occurred on a great variety of junipers throughout the Niagara Peninsula and on oriental arbor vitae at St. Catharines, Ont. The white peach scale *Pseudaulacaspic penagona* (Targ.) was found in two small infestations on mulberry at Beamsville, Ont. *Lecanium corni* Bouché attacked *Taxus* sp. and other hosts in southern Ontario. *Gossyparia spuria* (Mod.) injured elm and *Pulvinaria vitis* (L.) injured silver maple at St. Jean, Que.

TENT CATERPILLARS AND WEBWORMS.– In southwestern British Columbia, *Malacosma pluviale* (Dyar) was very abundant on shade trees. In most of Eastern Canada, *Malacosoma* spp. were at a low level of abundance. In Manitoba and eastern Ontario, *Hyphantria textor* Harr. was rather more numerous than in 1954. In eastern Quebec and New Brunswick, *Archips cerasivorana* (Fitch) occurred in small numbers.

THRIPS.– Thrips generally were more abundant than usual in Saskatchewan. *Taeniothrips simplex* (Mor.) occurred in reduced numbers in Manitoba, but was more abundant than usual in southwestern Quebec.

A VARIEGATED FRITILLARY.– *Euptoieta claudia* Cram. attacked pansies at Brandon and Portage la Prairie, Man.

VIRGINIA-CREEPER LEAFHOPPER.– *Erythroneura ziczac* Walsh was present in the usual heavy infestations on Virginia creeper at Kamloops, B.C., and in Alberta.

WALNUT CATERPILLAR.–In Ontario, *Datana integerrima* G. & R. was conspicuous on walnut trees in the Niagara Peninsula and near Pickering.

INSECTS ATTACKING MAN AND LIVESTOCK

BAT BUG.– An infestation of *Cimex pilosellus* (Horv.) was reported from Aylmer, Que.

BED BUG.–Reports from almost all provinces indicated that *Cimex lectularius* L. is still a fairly frequent pest.

BITING MIDGES.– Several species of *Culicoides* were added to the known fauna of British Columbia. At Kamloops, *C. variipennis* Coq. which had been extremely numerous in 1954, was scarce; *C. yukonensis* Hoff. and *C. obsoletus* (Mg.) were most prominent; *C. palmerae* James was taken for the first time. *Leptoconops* sp., probably *kerteszi* Kieff., attacked man at Dog Creek.

BLACK FLIES.– In British Columbia, black flies were troublesome in most wooded areas. In the Kootenays, thousands of acres of rangeland about Horsethief Creek were rendered untenable. In Saskatchewan, black flies caused more trouble than usual. Two small-stream species. *Simulium venustum* Say and *S. vittatum* Zett., occurred in widespread outbreaks for the first time in many years, apparently in association with greatly increased run-off, particularly in the Qu'Appelle Valley in southeastern Saskatchewan. No livestock fatalities due to these species were reported, but milk production declined and outdoor workers were attacked. After July 1, *S. vittatum* was the most widespread and abundant species in the Province but no damage was reported. In northwestern agricultural areas of Saskatchewan, *S. luggeri* N. & M. was the most abundant species around cattle in late June. An unusually lengthy spring outbreak of *S. arcticum* Mall. was followed by an unusually late summer outbreak. Five animals were known to be killed by this species. In Manitoba, black flies were unusually abundant and troublesome in western agricultural districts, particularly on the Souris River and its tributaries, and in Pipestone Creek. Adults were troublesome to range cattle. In late May *Cnephia dacotense* (D. & S.) was the most numerous species, but during June *S. vittatum* and *S. luggeri* predominated. In eastern Ontario, black flies were much less numerous than in most years. In the Baie Comeau area of Quebec, 21 species, including two undescribed species of the genera *Cnephia* and *Simulium*, were collected. In Newfoundland black flies were very troublesome all summer.

BLOW FLIES AND FLESH FLIES.– In cases of myiasis in Alberta, a larva of *Cuterebra* sp. was recorded from mink at Lac la Biche; larvae, probably of *Wohlfahrtia opaca* Coq., from a baby at Calgary; larvae of *Muscina* sp., probably *stabulans* (Fall.), from the faeces of an infant at Yellowknife; and near Edmonton two larvae of *Sapromyia citellivora* (Shewell) from the ear of a human.

BOT FLIES.—*Gasterophilus* spp. persisted as common pests of horses, which continued to diminish in numbers.

CATTLE GRUBS.—In British Columbia and Alberta, infestations of *Hypoderma lineatum* (De Vill.) and *H. bovis* (L.) were substantially reduced; in the principal study herd the mean infestation was 30 larvae per animal, compared with 54 in 1953 and 64 in 1954. Survival from the hypodermal stage was about 50 per cent compared with 25 per cent in 1954; emergence began at the latest date observed since observations commenced in 1946. Pupal survival also was high, about 65 per cent of *H. lineatum* and 50 per cent of *H. bovis* producing flies. Elsewhere in Canada warbles continued to be a common pest of cattle, although populations had greatly diminished where control measures had been consistent for two or three years.

A EUROPEAN PIGEON BUG.—An insect, believed to be *Cimex columbarius* Jenyns, occurred in large numbers in an old building at Stamford Centre, near Niagara Falls, Ont. The building had been used as a poultry house.

FLEAS.—*Ctenocephalides* spp. were widely recorded in household infestations, over two dozen reports having been received from the Ottawa area alone. At Oliver, Alta., *Ceratophyllus gallinae* (Schr.) dispersed from a sparrow's nest and attacked children. The species was also taken on poultry at Lashburn, Sask.

LICE.—*Linognathus vituli* (L.), *Haematopinus eurysternus* (Nitz.), and *Bovicola bovis* (L.) were all reported infesting cattle in Western Canada. The Western Stock Growers Association rated cattle lice one of the four major problems of the industry. These species are a problem also on stabled stock in Eastern Canada. A few infestations of chicken lice were reported and *Phthirus pubis* (L.) was recorded in Alberta.

MITES.—The chicken mite, *Dermanyssus gallinae* (Deg.), was commonly reported on chickens, and at St. Anne de la Pocatiere, Que., it severely infested turkeys. Dispersals of this mite from birds' nests into dwellings and subsequent attacks on humans were reported in Saskatchewan, Ontario, and Nova Scotia. In British Columbia the species was reported by one commercial poultryman to be showing evidence of developing strains resistant to BHC. A persistent infestation of the northern fowl mite, *Bdellonyssus sylviarum* (C. & F.), was recorded in Saskatchewan. A very heavy infestation of mites of the family Europodidae occurred on a mink farm at Shelburne, N.S. The group feeds on mosses, lichens, and fungi and related species are alternate hosts for some tapeworms. In Ontario the tropical rat mite appeared to have become established in a tenement building in Trenton.

MOSQUITOES.—In British Columbia, populations of snow-pool mosquitoes were small, but, as in 1954, a late and prolonged run-off favoured development of vast numbers of flood-water mosquitoes, *Aedes* spp., which persisted throughout the summer. The Kootenays and the Columbia and Fraser valleys all experienced heavy infestations. In the area about Edmonton, Alta., mosquitoes were less troublesome than usual. In Saskatchewan early summer requests for information on control were numerous and in late summer a build-up in populations was followed by outbreaks of western equine encephalomyelitis in southeastern and central agricultural areas. More than 40 human cases were suspected. *Aedes spencerii* (Theo.) was reported to be the most abundant mosquito in early summer and *A. vexans* (Mg.) in late summer. In Manitoba *A. spencerii, A. vexans, A. dorsalis* (Mg.), and others were unusually common and troublesome in all areas because of heavy spring rains. In Ontario, mosquitoes were generally troublesome early in the summer, but dry weather reduced populations by early July. In eastern Ontario and in Prince Edward Island, populations were smaller than in 1954.

SHEEP KED.—No severe attacks were reported, but infestation was believed to be fairly general. At shearing time in Alberta, lambs were more heavily infested than adults and fleeces were inferior to those of uninfested flocks.

SNIPE FLIES.—Formerly regarded as pests at higher altitudes, snipe flies were taken at Shuswap Lake, B.C., 1150 feet above sea level, and complaints were received also from Hope, B.C., at the 300-foot level.

TABANIDS.—In eastern Ontario, *Chrysops* spp. were more common than in 1953 or 1954 and were major pests of livestock and humans. *Tabanus* spp. were active but less numerous than in 1953 or 1954.

TICKS.—In British Columbia the Rocky Mountain wood tick, *Dermacentor andersoni* Stiles, appeared to be increasing and spreading. Large populations appeared in the Kamloops and Douglas Lake areas, where they had not been seen before. At the latter site, cattle herds had ranged for the previous 30 years without trouble. In 1955, 400 head became heavily infested, involving paralysis of 30. Prompt spraying with BHC saved all but three animals.

Six recoveries from tick paralysis in children and one death were reported in British Columbia. It had been known for some years that deer and mountain sheep in British Columbia harboured large populations of the ear tick, *Otobius megnini* (Dugès). In the spring of 1955, the deaths of five cattle in the Shuswap Lake area were attributed to infestations of this tick. Later another infestation occurred at Lumby and cattle at Adams Lake were infested. The winter tick, *Dermacentor albipictus* (Pack.), appeared to maintain its usual status. In Alberta a specimen of the lone star tick, *Amblyomma americanum* (L.), was removed in an Edmonton hospital from a man recently returned from Fredericktown, Mo., U.S.A. In Saskatchewan, specimens of the American dog tick, *Dermacentor variabilis* (Say), were taken on a child and a dog, and in Manitoba the species was recorded on several occasions. In Ontario, *Ixodes cookei* Pack. was taken twice on humans and occasionally on dogs. In one instance, at Marysville, eight specimens were removed from a man seeking a remedy for a sick stomach. The species was recorded also at Verdun, Que. In Ottawa, Ont., the brown dog tick, *Rhipicephalus sanguineus* (Latr.), infested several dogs and dwellings.

HOUSEHOLD INSECTS

ANTS.—Reports of ant infestations in buildings, lawns, and gardens were numerous, as usual, and in southern areas of Ontario and Quebec seemed to be more abundant than usual, probably in association with unusually warm, dry weather. *Lasius subumbratus* Vier. appeared in large numbers at Vernon and Kelowna, B.C.; *Tapinoma melanocephalum* (F.) infested an apartment at Windsor, Ont.; *Tetramorium caespitum* (L.) infested a dwelling at Windsor, Ont., and was probably a first record in Canada. *Camponotus* spp, were commonly reported. *Monomorium pharaonis* (L.) was identified on several occasions in Ontario, Quebec, and Prince Edward Island, and *Solenopsis molesta* (Say) was associated with three infestations in buildings at Ottawa, Ont.

BEES AND WASPS.—Bees and wasps in dwellings were a common source of annoyance and were often difficult to eradicate.

BOXELDER BUG.—In British Columbia, *Leptocoris trivittatus* (Say) was not observed at Kamloops, but was present in the Okanagan Valley from Vernon southward. In Alberta it caused considerable annoyance in the Pincher Creek area. Two infestations were reported in Saskatchewan. In southern Ontario the insect was more troublesome in dwellings than ever before.

CARPET BEETLES.—The black carpet beetle, *Attagenus piceus* (Oliv.), was a common and injurious household pest from coast to coast. *Anthrenus scrophulariae* (L.), fairly commonly reported in Eastern Canada, was of secondary importance. *Anthrenus museorum* (L.) occurred in an apartment at Ottawa, Ont.

CLOTHES MOTHS.—Both *Tinea pellionella* (L.) and *Tineola bisselliella* (Hum.) persisted as important fabric pests, but apparently were less injurious than carpet beetles.

CLUSTER FLY. — *Pollenia rudis* (F.), recorded in a few infestations in Ontario and Quebec, apparently was much less abundant than usual.

COCKROACHES.—The brown-banded roach, *Supella supellectilium* (Serv.), was recorded from Edmonton, Alta.; Saskatoon, Sask.; and Ottawa and Carleton Place, Ont. The species had not previously been reported in any of these provinces. *Blattella germanica* (L.) was widely distributed and a common pest. *Parcoblatta pennsylvanica* (Deg.) invaded several summer cottages in eastern Ontario, and *Blatta orientalis* L. severely infested a large building in Leamington, Ont.

CRICKETS.—Camel or cave crickets, *Ceuthophilus* spp., occurred fairly frequently, usually in basements, being reported from Alberta eastward to Quebec. *Acheta domestica* (L.) was reported in Ottawa and Toronto, Ont., and Montreal, Que. In Toronto it infested all units of a seven-storey apartment building. *Acheta assimilis* F. was an occasional invader.

DRUG-STORE BEETLE.—Occasional infestations of *Stegobium paniceum* (L.) were reported from Saskatchewan, Manitoba, Ontario, Quebec, and Prince Edward Island.

FRUIT FLIES.—*Drosophila* spp. were very numerous in fruit stores and dwellings in Ontario.

GROUND BEETLES.—In Saskatchewan, *Stenolophus conjunctus* (Say) and *Bembidion* sp. occurred commonly in dwellings. In Manitoba, *Trichocellus ruficrus* (Kby.) infested cracks in the flooring of an old house. At Ottawa, Ont., the staphylinid *Deleaster dichrous* (Grav.) occurred in two dwellings.

HOUSE FLY.—Populations of *Musca domestica* L. remained at a comparatively low level in most areas.

HOUSE CENTIPEDE.—Several specimens of *Scutigera cleoptrata* (L.) were received from points in Ontario and Quebec.

LARDER BEETLE.—*Dermestes lardarius* L. was a fairly common household pest and in many cases the food source was believed to be dead insects or other concealed protein material.

MANURE FLIES.—Adults of a species of Borboridae were numerous in the curing room of a cheese factory near Almonte, Ont.

MITES.—The clover mite, *Bryobia praetiosa* Koch, was a major nuisance in dwellings, according to reports from almost all provinces.

PLASTER BEETLES. — *Aridius nodifer* (Westw.) infested a new apartment building at Halifax, N.S., and two infestations were recorded at Ottawa, Ont. *Microgramme ruficollis* (Marsh.) was recorded from Montreal, Que.

SILVERFISH.—Reports of infestations of Lepismatidae were received from all provinces except Manitoba. In Ottawa, Ont., several new apartment buildings were generally infested and inquiries were received from 24 householders.

SPIDER BEETLES.—In Prince Edward Island a heavy infestation of *Niptus hololeucus* (Fald.) occurred in a church. Breeding had occurred in dry pigeon manure, some of it probably 75 years old. *Ptinus villiger* (Reit.) emerged in large numbers from the wall spaces of a house at Flin Flon, Man., and *P. ocellus* Brown was found breeding beneath a floor covering at Sandy Cove, N.S.

STINK BEETLE.—*Nomius pygmaeus* (Dej.) invaded many homes in Matachewan, Ont., during July, forcing some residents to sleep elsewhere. The insects were believed to have been driven out of the forest by fires and attracted to the city's lights.

STRAWBERRY ROOT WEEVIL.—*Brachyrhinus ovatus* (L.) was occasionally reported as a household pest in Western Canada and in the St. Lawrence Gulf provinces, but in Ontario and Quebec it occurred in most unusual abundance, probably as a result of very warm, dry weather.

TERMITES.—*Reticulitermes flavipes* (Koll.) continued to spread in Toronto, Ont.

WOOD BORERS.—Powder-post beetles, mainly *Anobium* spp. and *Lyctus* spp., were reported from Kamloops, B.C., Halifax, N.S., and several localities in Ontario, where they caused considerable damage to buildings. *Callidium violaceum* (L.) infested the timbers of a building at Brockville, Ont. The wharf borer, *Nacerdes melanura* (L.), was recorded from Ottawa, Trenton, and Meaford, Ont., and Montreal, Que. *Xylotrechus undulatus* (Say) was reported once each from Saskatchewan and Manitoba.

STORED PRODUCT INSECTS

STORED GRAIN INSECTS.—The most serious stored product insect problems continued to be those associated with stored grain, there being a very large carry-over. The most important insect pest in Western Canada was again the rusty grain beetle, *Laemophloeus ferrugineus* (Steph.). This pest was common in farm-stored grain and in country elevators throughout Western Canada. It was intercepted in a number of cars on arrival at terminal elevators and was also found in five summer storage cargoes in lake vessels to a sufficient extent to necessitate unloading and fumigation. Fungus beetles, *Cryptophagus* spp. and *Lathridius* spp., the hairy spider beetle, *Ptinus villiger* (Reit.), and various grainmites were also found in large numbers. Insects found in isolated infestations included the saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.); the foreign grain beetle, *Ahasverus advena* (Waltl.); the meal moth, *Pyralis farinalis* (L.); the red flour beetle, *Tribolium castaneum* (Hbst.); the granary weevil, *Sitophilus granarius* (L.); the yellow mealworm, *Tenebrio molitor* L.; the Mediterranean flour moth, *Ephestia kühniella* Zell.; and others.

In Eastern Canada, infestations in terminal grain elevators were the most severe in several years. The insects involved were mainly the Indian-meal moth, *Plodia interpunctella* (Hbn.), and the tobacco moth, *Ephestia elutella* (Hbn.). Some infestations were limited to one species, but in others both were present. Exteremely warm weather during the summer resulted in an abnormal population build-up and a consequent high percentage of de-germed kernels in the upper layers of grain. Noticeable infestation was seen in oats and barley as

well as in wheat, although damage to wheat was by far the heaviest. Counts of de-germed kernels ran as high as 54 per cent in the top foot of grain in some bins. In general, damage by the Indian-meal moth greatly exceeded that by the tobacco moth.

MILL AND FEED WAREHOUSE INSECTS.—In flour mills the confused flour beetle, *Tribolium confusum* Duv., and the flat grain beetle, *Laemophloeus pusillus* (Schönh.), continued to be the most important pests. In the small mills and where plant sanitation received less attention, the Mediterranean flour moth was frequently an important pest. The hairy spider beetle was found in a number of flour warehouses on the prairies, and in Quebec *Ptinus raptor* Sturm spoiled 200 bags of wheat meal. In a Saskatoon, Sask., warehouse, an aphid, *Myzus* sp. destroyed over 200 bags of sprouting onions imported from California.

In warehouses on the Pacific coast, the spider beetle *Ptinus ocellus* Brown was the most important pest. In warehouses in the Vancouver area there were also several infestations of the white-shouldered house moth *Endrosis lactella* (Schiff.); the brown house moth *Hofmannophila pseudospretella* (Staint.); and *Aphomia gularis* Zell.

FOOD-INFESTING INSECTS.—The most commonly reported insect in this group was the saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.), which was a major nuisance. Other infestations involved the flour beetles *Tribolium destructor* Uytten. and *T. confusum* Duv.; the larder beetle, *Dermestes lardarius* L., the hairy spider beetle, the yellow mealworm, the Indian-meal moth, the rusty grain beetle, the German cockroach; the bean weevil, *Acanthoscelides obtectus* (Say); and other minor pests.

MISCELLANEOUS.—In Saskatchewan the red flour beetle, *Tribolium castaneum* (Hbst.), was reported from McCord and Willowbunch infesting hammer-milled oat straw in barn lofts. At Willowbunch the beetles were reported to be abundant throughout the house, barn, and outbuildings as well as among the straw. A single specimen was found in a sample of rye from Limerick. These were the first records at the Saskatoon laboratory of this species in the Province. In Manitoba, the dried-fruit mite, *Carpoglyphus lactis* (L.), severely infested aprpoximately 300 supers and combs of bee equipment at Potage la Prairie. The mites were apparently feeding on pollen. At Ottawa, Ont., larvae of the Indian-meal moth infesting stored honey comb were heavily parasitized by *Mesostenus gracilis* Cress., *Horogenes kiehtani* (Vier.), and *Apanteles nephoptericis* (Pack.).

NOTES ON SOME NEMATODE OCCURRENCES

The sugar-beet nematode, *Heterodera schachtii* Schmidt, 1871, was not found outside the areas previously reported in Ontario. On the other hand, the oat-cyst nematode, *Heterodera avenae* (Lind, Rostrup & Ravn, 1913) Filipjev, 1934, was found attacking oats at Tupperville, Ont. Previously this species had not been found west of the Waterloo area. There was no record of the golden nematode, *Heterodera rostochiensis* (Wollenweber, 1923) Franklin, 1940, in Canada. The northern root-knot nematode, *Meloidogyne hapla* Chitwood, 1949, was recorded from shasta daisy roots from Port Burwell, Ont., and from strawberry roots from Kentville, N.S.; and caused severe galling of carrots near Chatham, Ont.

Of the spiral nematodes, *Rotylenchus robustus* (deMan, 1880) Filipjev, 1934, was found in strawberry soil at Ottawa, Ont., and Fredericton, N.B.; in wheat soil from Lake Lenore, Sask.; in buckwheat soil from Fallowfield, Ont.; and in very large numbers around oat roots from Wyman, Que. *R. erythrinae* (Zimmermann, 1904) Goodey, 1940, was found around the roots of *Agrostis* sp. from Hepburn, Sask.; of white clover from Pierce's Corners, Ont.; of wheat from Lake Lenore, Sask.; of flax from Cardston, Alta.; of alfalfa from Shawville, Que.; of red clover from Hazeldean, Ont., and Macdonald College, Que.; in oat soil from Tupperville, Ont., and Wyman, Que.; and from soil around a tamarack tree at Pierce's Corners, Ont. *Hoplolaimus coronatus* Cobb, 1923, heavily infested pasture sod from Brandon, Man.

Records of root-lesion nematodes included *Pratylenchus pratensis* (deMan, 1880) Thorne, 1949, on oats at Agassiz, B.C.; in soil around alfalfa roots at Shawville, Que.; and in soil of strawberry roots at Kentville, N.S. *Pratylenchus penetrans* (Cobb, 1917) Sher & Allen, 1953, was found in soil of apple orchards at Oliver and Kelowna, B.C., and Ottawa, Ont.; of prune and cherry at Summerland, B.C.; of peach at Peachland, B.C.; of corn at Brandon, Man.; in grass sod from Langley Prairie, B.C.; on strawberry roots at Kentville, N.S., and Keating Valley and Hatzic, B.C.; on red clover roots at Ottawa, Ont.; and around wheat roots at Lake Lenore, Sask. *P. minyus* Sher & Allen, 1953, was recorded on cherry, pear, and prune at Blackburn, Ont.; and around chrysanthemum roots at Peters Corners, Ont. Species of *Radopholus* were found around strawberry roots at Kentville, N.S., and wild rice roots near Richmond, Ont.

Of the subfamily Tylenchinae, *Tylenchus filiformis Bütschli*, 1873, was recorded in grass sod at Blackwell, Ont., and *Tylenchus costatus* deMan, 1921 near wild cherry roots at Blackburn, Ont. *Psilenchus hilarulus* deMan, 1921, was found in red clover soil at Hazeldean, Ont. Records of stunt nematodes were considerably extended as follows: *Tylenchorhynchus dubius*

(Bütschli, 1973) Filipjev, 1936, from around alfalfa and red clover roots at the Central Experimental Farm, Ottawa; in riverside soil from Picture Butte, Alta.; and from soil of *astitae* sp., London, Ont. *Tylenchorhynchus claytoni* Steiner, 1937, was recorded from Chinese elm at Ottawa and in riverside soil from Picture Butte, Alta. *Tylenchorhynchus acutus* Allen, 1955, was found in chrysanthemum soil at Brandon, Man., and in riverside soil from Picture Butte, Alta. *Tylenchorhynchus brevidens* Allen, 1955, was found around red clover and corn roots at the Central Experimental Farm, Ottawa; around red clover roots near Manotick, Ont.; in cherry soil, Penticton, B.C.; in pear soil, Summerland, B.C.; and in sugar-beet soil near Lethbridge, Alta. *Tylenchorhynchus leptus* Allen, 1955, was found associated with wheat roots from Lake Lenore, Sask. *Tylenchohynchus maximus* Allen, 1955, was numerous in pasture soil from Fallowfield, Ont., and was present in oat soil from Manotick, Ont., in grass sod from Arden, Ont., and in timothy sod from York, P.E.I., and Quinnville, Que.

There was no indication of spread of infestation of the potato-rot nematode, *Ditylenchus destructor* Thorne, 1945, in Prince Edward Island during 1955. This species is not now considered a serious threat to the potato industry.

Species of ring nematodes recorded included the following: *Criconemoides lobatum* Raski, 1952, collected on wheat from Lake Lenore, Sask.; on red clover from Hartland, N.B., Hazeldean, Ont., and Talon and Macdonald College, Que.; on strawberry from Stanstead, Que.; in timothy sod from Quinnville, Que.; in pasture sod from Merivale Station, Ont.; and in *Fragaria vesca* soil from Kentville, N.S. *Criconemoides annulifer* (deMan, 1921) Taylor, 1936, collected from English holly soil from Brentwood, B.C. *Criconemoides curvatum* Raski, 1952, taken in nursery soil from Victoria, B.C.; on red clover roots from the Central Experimental Farm, Ottawa, Macdonald College, Que., and Danford Lake, Que.; on oats from Preston, Ont.; and on strawberry from Fredericton, N.B. *Criconemoides xenoplax* Raski, 1952, recorded from peach soil from Harrow, Ont., and maple tree roots on the Central Experimental Farm, Ottawa.

Records of loose-coated nematodes included *Hemicycliophora similis* Thorne, 1955, on white clover from Stittsville, Ont., pin cherry from Blackburn, Ont., and in large numbers near maple roots at Old Chelsea, Que. *Hemicycliophora uniformis* Thorne, 1955, was identified from soil near a tamarack tree at Pierce's Corners, Ont.

Pin nematodes, *Paratylenchus* sp., were numerous around red clover roots at Macdonald College, Que., and were recorded in soil from the following: prune, at Summerland, B.C.; peach at Peachland, B.C.; strawberry at Hatzic, B.C.; raspberry at Matsqui, B.C.; prairie grass at Hepburn, Sask.; corn and red beet (numerous) at the Canada Experimental Farm, Brandon, Man.; red clover at the Central Experimental Farm, Ottawa, Ont., and Hazeldean, Ont.

A flanged-spear nematode, *Boleodorus thylactus* Thorne, 1941, was found in soil of prune and pear orchards at Summerland, B.C., and in soil near a maple tree at the Experimental Farm, Ottawa, Ont.

The chrysanthemum nematode, *Aphelenchoides ritzema-bosi* (Schwartz, 1911) Steiner, 1932, was found in chrysanthemum leaves at Peter's Corners, Ont.

Records of dagger nematodes included *Xiphinema americanum* Cobb, 1913, found around the roots of the following: alfalfa (numerous), Shawville, Que.; oats, Wilson's Corners, Que.; wheat, Lake Lenore, Sask.; vetch, wild rice, milkweed, and maple tree, Ottawa, Ont.; peach tree, Leamington, Ont.; strawberry and English holly, Vancouver Island, B.C.; blackberry (numerous) Otter Lake, Que.; and lawn sod, Agassiz, B.C.

Large numbers of *Longidorus elongatus* (deMan, 1876) Thorne & Swanger, 1936, were found around maple tree roots on the Central Experimental Farm at Ottawa, and *Longidorus sylphus* Thorne, 1939, from the soil around strawberry roots at Agassiz, B.C.

Records of free-living nematodes in soil included the following: a forked-lip nematode, *Chiloplactus symmetricus* (Thorne, 1925) Thorne, 1937, in prune and pear orchards at Summerland, B.C., and an apple orchard at Kelowna, B.C. *Panagrolaimus subelongatus* (Cobb, 1914) Thorne, 1937, in a pear orchard at Summerland, an apple orchard at Oliver, and an apricot orchard at Osoyoos, B.C. Records of spear nematodes were numerous and included *Dorylaimus monohystera* deMan, 1880, from oat soil at Preston, Conestogo, and Aurora, Ont.; apple soil at Okanagan, B.C.; grass sod at Ottawa, Ont.; a sod bank north of Arden, Ont.; beach soil at Carleton, Que.; pasture sod south of Hepburn, Sask.; riverside soil east of Picture Butte, Alta.; riverside sod north of Taber, Alta.; and grass sod at Jasper, Alta. *Dorylaimus bastiani* Bütschli, 1873, was recorded from grass sod, Ottawa, Ont.; oat soil, Preston, Ont.; weed soil, Little York, P.E.I.; and lawn sod, Winnipeg, Man. *Dorylaimus intermedius* deMan, 1880, was found in meadow sod from Amherstburg, Ont.; in wheat soil near Winnipeg, Man.; and in streamside soil east of Hope, B.C. *Dorylaimus carteri* Bastian, 1865, and *Dorylaimus angulosa* Thorne & Swanger, 1936, were also found in streamside soil east of Hope, B.C. Other records of dorylaimids included *Pungentus monohystera* Thorne & Swanger, 1936, in timothy and grass sod from Little York, P.E.I.; in meadow sod from St.

Vallier, Que.; and in lawn sod from Agassiz, B.C. *Pungentus pungens* Thorne & Swanger, 1936, occurred in mountainside soil near Summit, B.C., and *Pungentus* spp. in peony soil, Ayer's Cliff, Que.; in meadow sod (larvae only), St. Vallier, Que., and in soil near a maple tree, Ottawa, Ont. The basket-headed nematode, *Carcharolaimus teres* Thorne, 1939, was found in wheat soil at Brandon, Man., and riverside sod north of Taber, Alta. *Tylencholaimellus magnidens* Thorne, 1939, was found in wheat soil north of Carmel, Sask., and *Tylencholaimellus striatus* Thorne, 1939, in a clover field at Hazeldean, Ont. Incidental records included *Amphidelus* sp. from apple soil at Kelowna, B.C.; *Dorylaimellus* sp. from apple soil at Osoyoos, B.C.; *Diphtherophora* sp. in apple soil and from near a maple tree at Ottawa, and in apple soil at Point Pelee, Ont. *Triphlonchium* sp. was found near a tamarack tree at Pierce's Corners, Ont.; *Wilsonema* sp. from strawberry soil at Keating, B.C.; and *Paraphelenchus* sp. from apple soil at Oliver, B.C., and from clover soil at Hazeldean, Ont.

Included in records of predacious nematodes were *Mononchus parabrachyuris* Thorne, 1924, in clover soil from Merivale, Ont.; *Mononchus brachyuris* (Bütschli, 1873) Cobb, 1917, in wheat soil at Coaldale and Tyrs, Alta., and at East Winnipeg, Man.; in soil from Harrow and Blackburn, Ont.; and in lawn soil from Agassiz, B.C. *Mononchus papillatus* (Bastian, 1865) Cob, 1916, in soil from Hornepayne and Blackburn, Ont., and from Agassiz, Vancouver and Ladner, B.C. *Mononchus sigmaturus* Cobb, 1917, in greenhouse soil with roses at Moncton, N.B., and in celery soil from Armstrong, B.C. *Mononchus longicaudatus* (Cobb, 1893) Cobb, 1916, in apple orchard soil from Kelowna, B.C. *Aporcelaimus vorax* Thorne & Swanger, 1936, in orchard soil at Kentville, N.S., in lawn sod at Agassiz, B.C., and with carrot rust fly larvae at Bradford, Ont.

Records of parasites and associates of insects included *Spherularia bombi* Dufour, 1837, from abdominal cavity of *Bombus ternarius* Say at Saskatoon, Sask.; *Aphelenchulus reversus* Thorne, 1935, from abdominal cavity of *Dendroctonus pseudotsugae* Hopk. at Vernon, B.C.; *Bradynema rigidum* (Van Siebold) Zur Strassen, 1892, from abdominal cavity of *Pseudohylesinus nebulesus* at Vernon, B.C.; *Aphelenchoides latus* Thorne in frass of *Dendroctonus pseudotsugae* Hopk. at Vernon, B.C.; and *Rhabditis obtusa* Fuchs, 1915, in frass of the same insect at Vernon, B.C.

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THE SOCIETY

MEETINGS, MEMBERS AND FINANCES

PROCEEDINGS OF THE NINETY-SECOND ANNUAL MEETING OF THE ENTOMOLOGICAL SOCIETY OF ONTARIO

The 92nd annual meeting of the Entomological Society of Ontario was held in War Memorial Hall, Ontario Agricultural College, Guelph, Ontario on 31 October, 1 and 2 November, 1955.

Registration began at 10:00 a.m. on 31 October and the meeting opened at 1:30 p.m. Professor R. H. Ozburn, President of the Society was in the chair and introduced Dr. J. D. MacLachlan President of the Ontario Agricultural College who welcomed all members and friends of this Society to the Ontario Agricultural College.

At the request of the members the President of the Society named the following committees:

Resolutions Committee
Mr. A. G. McNally, Chairman
Dr. H. L. House
Mr. W. G. Garlick

Nominations Committee
Mr. L. A. O. Roadhouse, Chairman
Mr. H. R. Boyce
Mr. H. W. Goble

The President then turned the chair over to Mr. G. F. Manson who conducted a very interesting symposium on the subject "Nutritional Requirements and Artificial Diets for Insects".

On Monday evening an informal get-together was held in Faculty Lounge and Mr. R. D. Bird of Brandon, Manitoba, showed a series of beautifully coloured slides which were enjoyed by all present. The local committee had set up small exhibits of biological interest and they were the centre of a great deal of interest and discussion. A light lunch, generously donated by the Ontario Agricultural College was served.

The Tuesday morning session was devoted to the presentation of papers as per programme. On Tuesday afternoon Professor A. W. Baker chaired a symposium which dealt with the subject "Changing Faunal Ranges". The views of the speakers of this group brought out a great deal of discussion and expression of opinions from the floor.

The Annual Banquet was held in the Elizabeth Room of the Royal Hotel. The chairman, Mr. W. A. Ross, introduced the speaker Mr. W. N. Keenan who gave a graphic account of "Plant Protection Developments in Mexico, Central America and Panama." The speaker was thanked by Dr. J. D. MacLachlan.

The annual general business meeting was held at 9:30 a.m. Wednesday, 2 November, 1955.

Following a motion by Mr. H. R. Boyce and Mr. W. Wressel the minutes of the annual business meeting held at Sault Ste. Marie, 3 November 1954, were adopted as read.

The financial statement for the year ending 28 October 1955 was presented by the Secretary-Treasurer. Following a motion by Mr. W. C. Allan and Mr. J. A. Oakley the statement was approved.

The President then called for the report of the Resolutions Committee. Mr. A. G. McNally, chairman, reported as follows:
Be it resolved that:

1. The Secretary forward a letter of appreciation to Dr. J. D. MacLachlan, thanking him for making available the facilities of the College and for providing such an excellent lunch on Monday evening.
2. The Secretary write a letter of condolence to the family of the late Mr. T. D. Jarvis.
3. The Secretary write a letter to the local press thanking them for their news coverage.
4. The heads of the O.A.C. Cafeteria and Dining Hall be thanked.
5. The members of the Programme and Local Committees be hereby thanked.

Following a motion by Mr. A. G. McNally and Mr. D. G. Peterson this report was adopted.

The President then asked for the report of the Nominations Committee. Mr. L. A. O. Roadhouse, Chairman, reported as follows:

Prof. R. H. Ozburn, Guelph.
Dr. A. S. West, Kingston.
Mr. G. G. Dustan, Vineland Station.
Mr. J. H. Follwell, Toronto.
Mr. W. A. Fowler, Ottawa.
Mr. R. W. Smith, Belleville.
Mr. W. Y. Watson, Sault Ste. Marie.

The President called for further nominations and Mr. R. B. Thompson nominated Mr. D. G. Peterson.

Mr. F. W. Gregory moved nominations close: seconded by Dr. W. E. Heming.

As only seven nominations were required, the President instructed that a written ballot be conducted and appointed Messrs. Boyce, McNally and Stearman to act as scrutineers.

While the ballots were being counted Dr. W. G. Friend gave a report on the status of the organization of the 10th International Congress of Entomology to be held at Montreal in 1956.

Mr. Boyce reported the result of the ballot as follows:

Messrs. Ozburn, West, Dustan, Follwell, Fowler, Smith and Watson, being the seven elected.

The meeting then adjourned.

The remainder of the morning was given over to paper reading as per programme. Dr. W. E. Heming in the chair.

The afternoon session was taken up with paper reading as per programme. Mr. H. R. Boyce in the chair.

At the start of this session a motion by Messrs. Baker and Ross "that following the expiration of the anticipated two year term of office by Dr. A. S. West, succeeding Presidents to hold office for only one year": was unanimously approved.

At the end of this session the President declared the Ninety-Second Annual Meeting of the Entomological Society of Ontario adjourned.

W. C. Allan.

EXHIBITS AT THE ANNUAL MEETING

At the 1955 Annual Meetings of the Entomological Society of Ontario, Dr. A. J. Musgrave arranged an interesting group of Exhibits in the faculty lounge at the Ontario Agricultural College.

The Department of Parasitology of the Ontario Veterinary College displayed some excellent 20 x papier-mache models showing life-history stages of the malaria mosquito, house fly and bedbug in appropriate habitats. The models, made in Japan, are used as teaching aids.

Dr. A. A. Kingscote, Head of the Department of Parasitology, also placed on display his private collection of large coleoptera. This collection included a number with striking cephalic or thoracic outgrowths.

Professor G. F. Townsend, Head of the Department of Apiculture, O.A.C., placed on continuous display kodachrome slides taken during visits to Dr. von Frisch at his laboratory in Munich and his summer home in the Austrian Alps. These slides depicted some of Dr. von Frisch's famous work on insect behaviour.

Dr. D. H. Pengelly exhibited representatives of five insect species from Southern Ontario. The accompanying data indicated that each record substantially increased the known range of the species ocncerned.

New Record	Insect	Previous Known Distribution
	(Apidae)	
Guelph, 1951, 1955 Orangeville, 1955	*Holcopasites calliopsidis* (Lindsley)	Iowa, Kans., Mont., Colo.
	(Megachilidae)	
Dyer Bay, 1955	*Osmia subaustralis subaustralis* Cress.	Alt. to N. Mex., west to B.C. and Calif. Mts.
Cayuga, 1947 (R. H. Burrage)	*Anthidium tenuiflorae tenuiflorae* (Ckll.	NW. Ter. Alta., Sask., Mont., S. Dak., Wyo., Nebr., Colo., B.C., Wash., Oreg., Calif.
	(Pompilidae)	
Sombra, 1952	*Cryptocheilus attenuatum* Banks	Iowa, Kans., Tex., Tenn., La.
	(Sphecidae)	
Orangeville, 1955	*Stictiella* (?) formosa (Cress.)	Kans., Okal., Tex.

Dr. Pengelly also exhibited some specimens of the Black Widow Spider, *Latrodectus mactans mactans* (Fabr.) first collected near Dyer Bay on Bruce Peninsula. They constituted a new record for Ontario.

Professor A. J. Musgrave exhibited a slide of the characteristic mycetomal micro-organisms of *Sitophilus granarius* (L.) stained in Delafields Haematoxylin and Eosin following pretreatment of the dried smear by Bouin's formol picro-acetic solution.

Mr. L. B. Smith, Stored Product Insect Unit, Ottawa, exhibited two specimens of the Indian meal moth, *Plodia interpunctella* (Hbn). One was a typical specimen, and the other a mutant with respect to eye colour. Mr. Smith submitted the following comments.

"No description of this mutation has been found in the literature although a similar mutation has been reported for *Ephestia kuhniella* Zell.

"The normal eye colour of *Plodia interpunctella,* as exemplified by the typical specimen, is dark brown. The eyes of the mutant were colourless although they appeared to be white against the dark brown background of the head of the moth. The position, size and shape of the eyes were identical in both moths.

"The thorax and abdomen of the mutant were yellow-brown whereas in the typical specimen they were dark grey. The significance of this difference is as yet unknown. All other parts of both specimens were normal in their size and colouration."

Dr. E. I. Sillman exhibited: (1) Specimens of second and third instar larvae of a species of *Cuterebra* infesting *P. leucopus;* (2) Specimens of white-footed mice showing the cavities in which the larvae were situated; and (3) a case-record of the transplantation of a larva from a white-footed mouse to a laboratory white muose (*Mus musculus)* with the preserved specimen of the white mouse. The white mouse showed, in conarst to the specimens of white-footed mice, an incompletely walled-off cavity accompanied by necrosis of surrounding tissues.

A. G. McNally.

[1]Kuhn, A. Caspari, E., and Plagge, E. 1935. Uber hormonale Gewirkungen bei **Ephestia kuhniella.**—Nachr. Geo. Wiss. Gottingen, Biol. 2.

ENTOMOLOGICAL SOCIETY OF ONTARIO FINANCIAL STATEMENT

RECEIPTS

Dues		$1002.15
Government Grant		300.00
Back Numbers		21.50
Bank Interest		9.34
		$1332.99
Bank Balance		
October 29, 1954	$690.31	
Cash on hand	10.00	
	700.31	
Less O. S. Cheques		
October 29, 1954	235.00	465.31
		$1798.30

EXPENDITURES

Printing Can. Ent.	$1066.00
Bank Exchange	4.85
Library Insurance	22.50
Library Assistance	150.00
Postage	39.00
Envelopes	28.31
Membership Cards	4.40
Binding	22.15
N.S.F. cheque	5.15
Steno. Assistance	10.00
Auditing	5.00
Miscellaneous	3.50
	$1360.86
Bank Balance October 28, 1955	437.44
	$1798.30

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[1]Died June 5, 1956

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INDEX

It is believed that all the well-known species mentioned in the text are listed here. Others may be found by referring to the Family, the genus, the crop, or the locality.

————o————

THE NINETY-THIRD
ANNUAL MEETING OF THE ENTOMOLOGICAL SOCIETY OF ONTARIO

will be held at the Ontario Agricultural College, Guelph.

A special session will be held on
"GLEANINGS FROM THE CONGRESS"
which will be in the form of discussions and descriptions of different parts of the Congress.

Paper reading sessions will be provided for those who wish to report recent work or work which was not reported at the Congress. The annual business meeting will also be held.

MAKE A NOTE OF THE DATE — 2 NOVEMBER 1956

ANNUAL REPORT
OF THE ENTOMOLOGICAL SOCIETY OF ONTARIO

AUTHORS' GUIDE

1. Authors should refer to papers in this volume for guidance on arrangement of material. Manuscripts should be typed double spaced on paper 8½ x 11. Main headings by the left hand margin, in capitals, subsidiary headings in italics.

2. Statements in the text that require confirmation by reference to other work should be written so that they are followed by a number (in brackets) which should be the number attached to the reference in "Literature Cited".

3. In order to make the "Literature Cited" of maximum possible benefit to entomologists in many parts of the world to which the Annual Report is sent, references should be listed alphabetically as follows:

Reference number in brackets, surname of author in capitals, initials of author, date in brackets, full title of paper as given by the author, a dash, name of the journal abbreviated according to the system adopted in the "World List of Scientific Periodicals", volume number underlined, colon, number of the first page of the article, period.

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For example the text of a paper may contain a statement like "many people find cockroaches repugnant (14)", or "Doe (14) claims that cockroaches are repugnant to many".

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(14). Doe, J. (1888) Some observations on cockroaches in houses.—Bull. ent. Soc. Guelph 5: 46.

4. In order to avoid embarrassment to the Society and the editor, authors describing work done under Government sponsorship are asked to get their local most senior officer to certify that the paper has been passed for publication.

5. Material accepted for publication in the Annual Report normally should not have been and should not subsequently be published elsewhere.

Insects

ANNUAL REPORT of the ENTOMOLOGICAL SOCIETY OF ONTARIO

Volume Eighty-Seven

1 9 5 6

(Published October, 1957)

PUBLISHED BY AUTHORITY OF
THE HONOURABLE WILLIAM A. GOODFELLOW, MINISTER OF AGRICULTURE FOR ONTARIO

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2. Correspondence about exchange of publications, or membership of the Society should be addressed to Secretary-Treasurer, Entomological Society of Ontario, Entomology and Zoology Department, Ontario Agricultural College, Guelph.

ANNUAL REPORT
of the
ENTOMOLOGICAL SOCIETY OF ONTARIO

Volume Eighty-Seven

1 9 5 6

(Published October, 1957)

Published by authority of
HONOURABLE WILLIAM A. GOODFELLOW
Minister of Agriculture for Ontario

EDITED BY: A. J. MUSGRAVE

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The Ninety-Third Annual Meeting of the Entomological Society of Ontario was held at the Ontario Agricultural College, Guelph, Canada on November 2, 1956.

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Volume 87

I. SUBMITTED PAPERS

OBSERVATIONS ON THE LIFE-HISTORY OF THE EASTERN FIELD WIREWORM, *LIMONIUS AGONUS* (SAY) (COLEOPTERA: ELATERIDAE), UNDER LABORATORY CONDITIONS[1]

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The eastern field wireworm, *Limonius agonus* (Say), is the principal species of wireworm in the light sandy soils of southwestern Ontario. It attacks most garden and field crops. Damage to row crops is usually more noticeable than to grains because of the smaller number of plants per unit area.

The biology of this species has been studied under field and laboratory conditions by various workers. Olson (9) investigated in some detail the life-history in New York. Lacroix (7), Morrill and Lacroix (8), Greenwood (4), Beard (1), and Kring (5) have published observations made in Connecticut. Kulash (6) made observations in Massachusetts.

The intensive cultivation practised in southwestern Ontario favors the species as the female usually oviposits in loose cultivated soil. By 1948 populations had so increased that a project was initiated at the Chatham laboratory to study life-history and control under local conditions. The observations on life-history reported herein were obtained between 1950 and 1956.

METHODS

A sandy loam soil of the type preferred by the eastern field wireworm was used in all laboratory studies. The soil was washed through a 60-mesh screen to facilitate recovery of eggs in all oviposition experiments. For rearing trials, it was sifted through either a 60- or a 20-mesh screen, depending on the size of larvae being reared. Soil moisture was adjusted to 12 to 15 per cent by weight, and maintained at this level by adding distilled water periodically.

Adults collected from the soil during the winter or during the spring flight were stored in moist soil at 35° to 40°F. until required for oviposition studies. Virgin females were mated in small glass dishes containing about half an inch of soil, exposed to sun or artificial light at 70° to 80°F. Two or more males were used with each female. Honey was supplied as food. The containers used for mating were also used for oviposition. The eggs were separated from the soil daily by washing through a 60-mesh screen. They were stored in distilled water at 35° to 40°F. until required for hatching.

Depth of oviposition was observed in quart-sized waxed cardboard containers filled with loosely compacted soil having a moisture content of about 15 per cent by weight. After 10 days, the eggs were collected by removing half-inch layers of soil.

Newly laid eggs were incubated in distilled water at 55°, 65°, 73°, 78°, and 83°F. The effect of stored eggs at 35° to 40°F. was also investigated.

All attempts to rear larvae hatched in the laboratory were unsuccessful between 1950 and 1953. The larvae were transferred to rearing bottles after being hatched in water or hatching normally in soil. None of the larvae survived when

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[1]Contribution No. 3549, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada; presented at the annual meeting of the Entomological Society of Ontario, Guelph, November 2, 1956. From a thesis submitted in partial fulfilment of requirements for the degree of Master of Science at the University of Western Ontario.

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fed on a wide variety of natural and artificial food materials. In 1954, larvae survived when eggs were laid in, or were transferred to, rearing bottles containing soil and viable timothy seed, *Phleum pratense* (L.). The larvae were isolated after 6 weeks and were fed on timothy and wheat seedlings. In October, 1954, a number were transferred outside to a large tile sunk in the ground, where they remained undisturbed until April, 1955. The remaining larvae were reared at 73° to 75°F. At each monthly examination the wireworms in the laboratory were weighed. Larvae hatched in the laboratory in 1955 were transferred to the outdoor rearing tile in October, where they were henceforth reared.

Exuviae were obtained by sifting the soil through a 60-mesh screen. Some, unfortunately, were mutilated by the larvae and could not be found. Each exuvium was stored with appropriate data in a small indentation covered with cellulose tape in a sheet of corrugated cardboard. Widths of exuviae were measured between the outer lines of the tali on the anterior end, and between the centres of the outer urogomphi on the posterior end. These two parts of the exuviae usually retained their original shape.

Field collected wireworms were reared at temperatures approximating those in the field to obtain information on larval development, moulting, and growth. Three sizes were selected: small, 10 mm. or less in length; medium, 11 to 15 mm.; and large, 16 mm. or longer. It was assumed that small larvae would probably be in the first year of development, the medium in the second year, and the large in the third. Larvae were fed on potato or potato and wheat.

Individual plaster-of-Paris chambers, which were kept in covered cases to prevent desiccation, were used in determining the pupal period at 65°, 73°, 78°, and 83°F.

ADULT

The adults of the eastern field wireworm may be stored in moist soil at 35° to 40°F. for a considerable period. Those collected in the field during the winter months usually survived until spring. Females collected during the spring flight survived approximately two months, males for one month.

The optimum temperature for mating is 70° to 80°F. Adults mate only in direct sun or artificial light.

The females usually oviposited on the bottoms of shallow oviposition chambers containing soil. Eggs were often placed alternately on either side of the tunnel made by the burrowing female. Rows of eggs were approximately half an inch apart, with the eggs one-quarter of an inch apart in the row.

Five females caught in coitus on May 10, 1952, and stored until July 5 laid from one to 42 eggs each per day. Similar observations were made in other years. The highest number of eggs laid by a female in 24 hours was 139.

In the laboratory most of the eggs were laid at depths of 1.0 to 3.0 in. in gently compacted sandy loam soil. In freshly worked soil in the field, Olson (9) found most eggs at approximately 2 in., with a few as deep as 9 in.; in sod, the greater number of eggs were deposited in the first inch of the soil. Turner (10) reported that females prefer to oviposit in loose soil as they have great difficulty burrowing in sod or heavy soil.

EGG

Ten eggs from each of 5 females averaged 651 microns in length and 517 microns in width.

The incubation period of eggs hatched in water at 65°F. was 40 to 58 days, and averaged 47.9 days. At 73°F., the period was 20 to 31 days, averaging 24.2 days; at 78°F., 16 to 26 days, averaging 19.8 days; and at 83°F., 14 to 25 days, averaging 18.2 days. At 55°F., only one egg out of 100 hatched after 71 days' incubation.

Viability of eggs was generally not affected by storage for two months in distilled water at 35° to 40°F.

LARVA

The first *L. agonus* larvae reared to maturity under laboratory conditions hatched about July 15, 1954, and a few emerged as adults in about one year. Adults were obtained from larvae reared continuously at 73° to 75°F., and from those reared outside from October, 1954, to April, 1955. A few larvae hatched in July, 1955, and reared outside from October emerged as adults in 1956. There is apparently no obligatory diapause. Completion of the life-cycle in one year is obviously not normal, but shows one extreme variation.

Newly hatched larvae are about 2.0 mm. long and 0.25 mm. wide. There are great differences in rate of growth among individuals. There is little or no association between weight and maturity since some of the smaller larvae that hatched in July, 1954, pupated one year later, whereas some of the larger ones continued to feed. The weights of males before pupation were 25.4 to 46.2 mg., and of females, 48.6 to 75.0 mg.

Of those reaching maturity in one year, there were more males than females.

Larvae that pupated in 1955 had six instars. The exuviae in each instar varied considerably in size, although there was little overlapping between instars (Table I). Application of a linear growth principle (3) indicated that the growth increment was linear rather than exponential, the percentage of error generally being higher when Dyar's rule (11) was applied. This observation

TABLE I

Widths in millimetres between tali on anterior end (A), and between centres of outer urogomphi on posterior end (P), of larval exuviae of *Limonius agonus* (Say).

	Instar											
	1		2		3		4		5		6	
	A	P	A	P	A	P	A	P	A	P	A	P
Number measured	1	1	8	8	6	6	6	6	8	8	10	10
Average width	.170	.160	.333	.274	.419	.313	.543	.427	.659	.567	.826	.694
Range	.170	.160	.26-.38	.25-.30	.28-.49	.28-.36	.46-.59	.33-.53	.56-.76	.48-.66	.77-.96	.61-.90
Calculated width (linear regression)	.179	.144	.304	.249	.429	.354	.555	.458	.680	.563	.805	.667
Percentage error	5.3	10.0	8.7	9.1	2.4	13.1	2.2	7.3	3.2	0.7	2.5	3.9
Calculated width (Dyar's rule)	.170	.160	.237	.217	.331	.294	.462	.398	.645	.539	.900	.730
Percentage error	—	—	28.8	20.8	21.0	6.1	14.9	6.8	2.1	4.9	9.0	5.2

may be erroneous as the numbers of specimens examined were small. As larvae that did not pupate in 1955 continued to moult, more than six instars may be expected.

Larval periods of field-collected larvae varied from three to five years or longer. These larvae survived up to four years under laboratory conditions. Other workers have estimated the duration of the larval period to be three to five years (9), or three to seven years (Dr. J. B. Kring, Connecticut Agricultural Experiment Station, New Haven, personal communication).

Laboratory rearing of field-collected larvae at temperatures approximating those in the field at 3 to 6 in. indicated two annual peaks of moulting, one in June and one in late July and early August. Since wireworms cease feeding for short periods before and after moulting, these peaks might account for periods of inactivity noted in the field by Beard (1).

If the larvae moult a minimum of six times under field conditions, and an average of twice a year, the minimum larval period is three years. In the laboratory, however, some larvae moulted several times during a year without showing any increase in length. Doubtless this occurs in the field under adverse conditions and results in extended larval periods.

PUPA

Mean pupal periods varied from 23.0 days at 65°F. to 12.3 days at 83°F. The rate of development was constant over this temperature range. These results suggest that the pupal period is 15 to 16 days under field conditions where soil temperatures in late July and early August average 77°F. at 3 to 6 in. in the soil (2).

SUMMARY

The eastern field wireworm, *Limonius agonus* (Say), was reared from egg to adult under laboratory conditions, viable timothy seed being used for food of newly hatched larvae and timothy and wheat seedlings after 6 weeks. The eggs hatched in approximately 24 days at 73°F.

The larvae usually moulted twice a year but there did not appear to be any marked association between instar and size. The life cycle usually required three to five years or longer, no diapause being observed. Larvae, however, were reared from egg to adult in one year. These larvae moulted six times before maturity. Of those reaching maturity in one year, there were more males than females.

The pupal period was calculated to be 15 to 16 days under field conditions.

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AN OUTDOOR STUDY CAGE FOR PHYTOPHAGOUS INSECTS[1]

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In designing a cage for field studies on the life-histories and habits of phytophagous insects, factors such as ease of assembly, convenience of storage, portability, and durability are commonly considered; much less commonly considered is the microclimate within the cage. It is generally assumed that the cage environment is more or less comparable with that of the open air. However, it has been pointed out by Peterson (1) that prevailing outdoor conditions are rarely approximated in cages, and comparatively few workers have reported on the actual climatic conditions in those that they have used.

The field study cage described in this paper can be easily assembled or taken apart, is readily stored, and is portable intact. In addition, it does not seriously alter the physical factors of the environment. It has been successfully used by the writer for the past three years in studies of the life-history and habits of the diamondback moth, *Plutella maculipennis* (Curt.).

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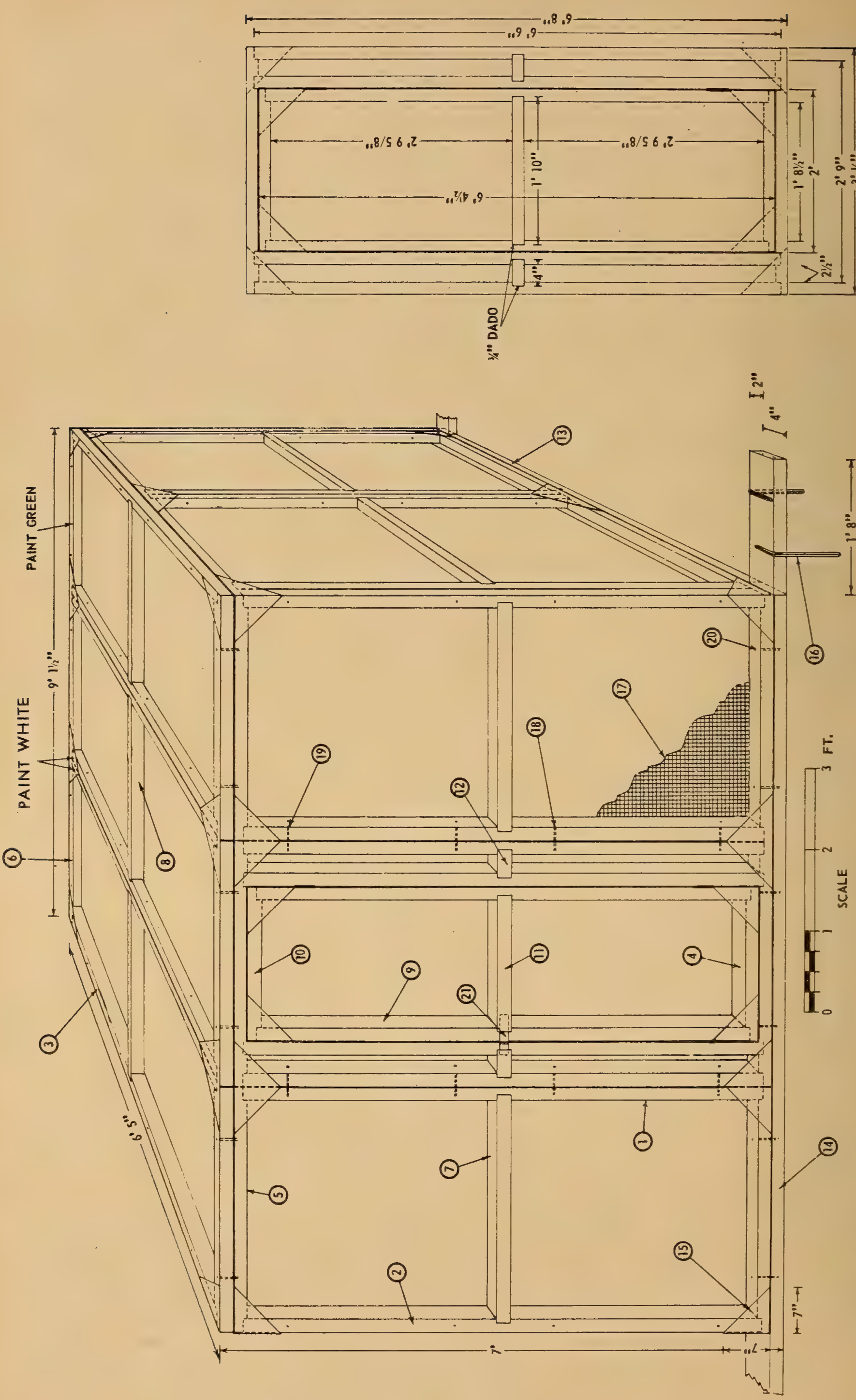

Fig. 1. Diagram of outdoor study cage. Left, entire cage. Right, door frame.

The cage (Fig. 1) covers an area of approximately 60 square feet. Its overall dimensions are 6 feet 5 inches X 9 feet 1½ inches X 7 feet. The walls consist of ten 36½-inch -X- 80-inch frames of 2-inch -X- 2-inch white pine braced at each corner by ¼-inch fir plywood; the roof, of three 36½-inch -X- 77-inch frames of similar construction. The door and wall frames are interchangeable. The 13 units are bolted together with ¼-inch -X- 4-inch machine bolts and brass wing nuts. To facilitate assembly, the corner braces may be painted in matching colours (one example given in Fig. 1). The cage rests on sleepers of 2-inch -X- 4-inch white pine; these are anchored to the ground by sleeper holders of ½-inch mild steel. The materials needed are shown in Table I.

Table I
Materials Needed for Outdoor Study Cage

Part number*	Part	Number required
1	Side for door frame	2
2	Side for wall frame	18
3	Side for top frame	6
4	End for door frame	2
5	End for wall frame	18
6	End for top frame	6
7	Middle rail for wall frame	9
8	Middle rail for top frame	3
9	Stile for door	2
10	Framing piece for door	2
11	Middle rail for door	1
12	Support for door frame	2
13	End sleeper	2
14	Side sleeper	2
15	Corner brace	56
16	Sleeper holder	8
17	36-inch screening	1**
18	Machine bolt	68
19	Wing nut	68
20	Wood screw	20
21	Hasp	1

* See Fig. 1.
** 29 yards.

The screening material is 20 -X- 20 mesh, natural-coloured Saran plastic (Chicopee Mills Inc., New York, N.Y.) with a filament diameter of .012 inches. It is fastened to the inner edge of each frame by narrow strips of ¼-inch fir plywood. This affords a continuous smooth wall on the inside of the cage and insects escaping from mating or oviposition containers are easily recaptured. Shelving for small cages may be fastened to the side walls by means of metal brackets on the middle rail.

To determine the influence of the study cage on the more important environmental factors, data were obtained on the following during investigations of the life-history of the diamondback moth: air temperature, relative humidity, rainfall, wind velocity, and light intensity. The cage was placed in an open area of sod adjacent to cultivated fields and there were no trees or artificial barriers in the vicinity. The readings were taken in the centre of the cage and at an arbitrary site approximately 60 feet upwind.

Air temperatures inside and outside the cage were recorded by two thermographs for a six-week period beginning on July 13, 1954. Each was placed in a louvered instrument shelter four feet above ground level. Relative humidities were recorded by means of a sling psychrometer, readings being taken once daily throughout May, 1956. Rainfall was recorded during May and June, 1956, by means of two funnel-type rain gauges placed 12 inches above ground. Wind velocities during a 60-minute period were compared once daily throughout May, 1956, with two Biram fan-type anemometers (Short and Mason Ltd., London, England) mounted on swivelled anemovanes. Light intensity measurements were made with a Norwood Director exposure meter (Director Products Corp., New York, N.Y.) once each day throughout May, 1956.

Table II shows that temperature, relative humidity, and rainfall in the cage were almost normal. Wind velocity and light intensity were reduced by 35 and 21 per cent respectively.

Table II

Average Daily* Meteorological Conditions Inside and Outside of Study Cage for one to two months, Merivale, Ont.

Location of instrument	Temperature, °F. Max.	Min.	Mean	Relative humidity, %	Rainfall, inches	Wind velocity, m.p.h.	Light intensity, foot candles
Outside cage	77.9	55.9	66.9	45.7	4.96	9.2	5,570
Inside cage	78.6	56.4	67.5	46.2	4.52	6.0	4,377

*Except that rainfall is given as the total for May and June, 1956.

The dimensions of the cage were chosen to meet requirements for studies on the life-history and habits of the diamondback moth. Other sizes may be more suitable for other species. Cages built to the preceding specifications have been used successfully at Ottawa during the past two years in studies on the clover seed midge, *Dasyneura leguminicola* (Lint.), the armyworm, *Pseudaletia unipuncta* (Haw.), and the onion maggot, *Hylemya antiqua* (Mg.), and at Marmora, Ont., in studies on the June beetle *Phyllophaga fusca* (Froel.).

The cage has withstood admirably the stress of weather conditions at Ottawa for the past 36 months. This has included several heavy falls of snow, and winds up to 75 m.p.h. during a hurricane in October, 1954.

The current cost of materials for the cage is approximately $67.00. About 40 man-hours are required for construction and assembly.

ACKNOWLEDGMENTS

The author is indebted to Messrs. G. Samson and C. Jackson of the Entomology Engineering Shop, Entomology Laboratory, Ottawa, for their expert help in designing and fabricating the study cage herein described. Drawings of the cage are by C. Jackson.

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CHANGES IN INSECT POPULATIONS IN SOUTHWESTERN ONTARIO[1]

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Changing faunal ranges is a topic that can be developed in many ways. From a geographic standpoint, one might ask the question "What causes certain indigenous organisms to become established in another locality?" An entomologist could develop this theme by pointing out the various known or suspected modes of introduction. These would include introduction via air currents and storms, ships, and aircraft from foreign countries, driftwood, foodstuff, nursery stock; in fact, almost anything mobile or capable of sustaining insect life is a potential means of insect introductions. The geneticist, physiologist, or climatologist could develop the subject by relating it to his own particular line of endeavor.

A few examples of changing faunal ranges from southwestern Ontario follow. Although factors contributing to the phenomena are suggested, the explanations are not necessarily adequate.

As southwestern Ontario is in the Carolinian portion of the Upper Austral Zone, sometimes referred to as the "banana belt" of Canada, it is not surprising that more insect species come to the attention of entomologists in a year in this area than in probably any other area of Canada. The location, from a geographic and climatic point of view, is ideal for the production of a wide range of diversified crops. As the production of these crops is intensified, it seems the number of insect species, whether noxious or beneficial, is also increased.

Some of the examples do not represent the more typical extension of a faunal range such as might accompany the extension in range of an established host crop, or the introduction of an alternate host crop. Faunal ranges can change for a species within a season and, in some remarkable cases, almost overnight, as for example, the potato leafhopper.

POTATO LEAFHOPPER, *EMPOASCA FABAE* (HARR.)

Although the economic status of the potato leafhopper in Canada has not been determined, it has been observed annually since at least 1922, when, under the name of *Empoasca mali* (LeB.), it was reported causing damage in apple orchards and potato fields in southern Ontario (1). During the past four years, when observations have been admittedly more intensified, the leafhopper has appeared in enormous numbers on all susceptible crops, particularly potato, forage, and bean. This is noteworthy because the pest has not been found overwintering north of the Gulf States and, indeed, many entomologists now believe the main overwintering areas to be in Central and South America, the West Indies, and Mexico. According to Wilson (7) it may be found in early May in southern Indiana, but does not reach the northern part of the state until later in the month. Near Chatham the first few adults are found in early June, and by mid July migrant adults and nymphs are usually present in incredible numbers. It remains as one of the most abundant economic species on vegetable and forage crops until it disappears in late September or October.

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[1]Contribution No. 3532, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada; presented as part of the symposium "Changing Faunal Ranges" at the 92nd Annual Meeting of the Entomological Society of Ontario, Guelph, October 31 - November 2, 1955.

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Probably the most interesting and perplexing aspect of the annual infestation is that it begins almost simultaneously in all susceptible crops over a large area. At certain times in June, the air must be filled with millions of leafhopper adults as they migrate into their Canadian feeding grounds; yet these huge populations that appear "out of nowhere" do not seem to deplete the numbers present in the mid-western or northeastern States. It does not seem reasonable to attribute this migration solely to the direction of the prevailing winds, or to the fact that host crops ripen progressively later as their northern range is extended. There must be other reasons to account for some of the leafhopper population in the United States leaving apparently suitable host crops and concentrating in a narrow strip along the north shore of Lake Erie (6). Certainly the influence of climate must enter to some extent; otherwise, host crops further north would normally be expected to support infestations. It would not be surprising that future fundamental research on the behavior of this species will reveal that the northward migration is triggered and sustained by a "physiological urge", and that more obvious contributing factors are but incidental.

The foregoing account of the potato leafhopper will undoubtedly give the impression that a great deal more work is required for an adequate understanding of the pest. That is precisely the situation. A large project in the United States is now in progress, with cooperating entomologists from Canada, the West Indies, Mexico, and Central and South America, to determine the general biology and the causes of migration of the potato leafhopper. Certainly the solutions to many of these problems are among the most interesting challenges in entomology today.

CORN EARWORM, *HELIOTHIS ZEA* (BODDIE)

A pest that has caused some concern in tomatoes is the corn earworm, which supposedly does not overwinter north of approximately Columbus, Ohio. It is almost an annual pest in corn in southwestern Ontario. In some years practically 100 per cent infestations develop in individual fields. Until 1953 the earworm had not been known to infest tomatoes in the Chatham area; yet in that year infestations developed in the fruits to such an extent that the tomato harvest was prematurely terminated. The infestation did not occur until the latter part of September. A factor that may have contributed to this unusual infestation was that the moth flight, as determined from light trap counts was the heaviest in years, the peak occurring in early September. The moths may have been from pupae that had survived the mild winter of 1952-1953. It seems more likely, however, that they were migrants from the south. Whatever the explanation for the heavy moth flight may have been, the main factor for the infestation developing in tomatoes appeared to be climatic or to concern the effect of weather on the growth of the corn crop. A hot, dry period prevailed in southwestern Ontario during August and September in 1953. This hastened the maturity of the corn, particularly the silks, and made it unattractive to the earworm. The insect then attacked the tomato, depositing its eggs on the green foliage of the plants. Further evidence that the weather played the dominant role in this case was afforded by a study of numerous corn fields. Fields that had to be reseeded for one reason or another in early summer were still green by the end of September. These fields were heavily infested with the earworm, a situation not uncommon in a normal growing season. However, earworms were not found in those fields that were planted in early summer and were dry by late September.

Stirrett (5) reported the presence of earworms in corn on July 19 in 1932, and stated that the insect had survived the winter of 1931-1932 in southern Ontario. This appears to be the only record of the species overwintering in

Canada. For the past three years officers of the Chatham laboratory have endeavored to settle this point by collecting between 1000 and 2000 earworms during October and placing these in overwintering cages containing suitable cover. So far none has survived.

This example is cited as an extension of range to a secondary host plant, and apparently is adequately explained on the basis of weather conditions and their effects on the primary host.

EUROPEAN CORN BORER, *PYRAUSTA NUBILALIS* (HBN.)

A very interesting example of a change in faunal range involving the second generation of the European corn borer has been studied by Wressell (10) in southern Ontario. Although a few second-generation borers were present in some years, it was not until about 1941 that they increased noticeably in numbers. By 1955 second-generation borers had increased to such an extent that they formed an important part of the borer population.

The appearance of the second-generation borer in Essex County was reported by Wishart first in 1942 (8) and again in 1943 (9), when a definite increase in summer pupation was observed. From annual field surveys conducted since 1946 Wressell (11) has shown that the second-generation borer is found in the five southernmost counties of Ontario. In 1949, in 97 per cent of the fields examined most of the borers passed through two generations.

Obviously there is no simple explanation of the much greater abundance of the second-generation borers in southwestern Ontario in recent years. In Ohio, Arbuthnot (2) has theorized that two strains are involved, that both strains may have been present, but that the less favored for survival (in this case the univoltine strain) may have reached the region before the multivoltine strain and apparently thrived. Then as the multivoltine strain gained in numbers it became the predominant strain. If this theory is correct, we may expect the eventual elimination of the univoltine strain from southwestern Ontario. This theory would suggest an extension of faunal range having as its basis the genetic constitution of the animal.

TOBACCO HORNWORM, *PHLEGETHONTIUS SEXTUS* (JOHAN.)

Another interesting example of the northward extension of the range of an economic insect is that of the tobacco hornworm. Tobacco has been grown as a crop of economic importance in southern Ontario since the latter part of the nineteenth century. From the early years, the tomato hornworm, *P. quinquemaculatus* (Haw.), has been an important pest, but the tobacco hornworm was not authentically reported until 1933, when Stirrett (6) identified three hornworms. It appears, from the little information available, that the tobacco hornworm has been present in Ontario for some time, although in small numbers.

In 1952 numerous complaints reached the Chatham laboratory that DDT was not controlling hornworms infesting tobacco in the Leamington area. Before 1952, DDT had given excellent control. It was soon learned that the "DDT-resistant hornworms" were tobacco hornworms, and that in some fields 70 per cent of the surviving worms were the tobacco hornworm. Field surveys conducted since 1952 indicate that the two species occur now in about equal numbers on tobacco in parts of southern Ontario.

Mr. R. J. McClanahan, of the Chatham laboratory, who has studied the tomato-tobacco hornworm complex, has suggested two possible explanations for the northward extension of the range of the tobacco hornworm. It may be

partly explained from a study of the control methods. Before 1947 these measures included hand-picking, cultural practices, and use of lead arsenate. None was selective in action. When DDT came into general use, farmers and investigators alike obtained excellent control of the tomato hornworm. The few tobacco hornworms present, always DDT-resistant, were not controlled. This probably contributed to the situation as it is today.

Another factor in the northward extension of the range of the tobacco hornworm may be climatic. There has been a gradual, but slight, increase in the winter temperature over many years, and it may be that these temperatures are high enough for the hornworm pupae to survive the winters. Whatever the reason, *P. sextus* has overwintered in outdoor cages at Chatham.

The tobacco hornworm is indigenous to North America and thus the extension of its northern limits is not comparable to the increase in range of an introduced pest. It has not been limited by the range of the host plant as tobacco is grown considerably north of the present limits of this hornworm. Observations in the next few years may yield data on the factors limiting the range of this insect.

COLORADO POTATO BEETLE, *LEPTINOTARSA DECEMLINEATA* (SAY)

Gibson *et al.* (3) documented the spread of the Colorado potato beetle in Canada and mentioned that Riley in 1871 described the beetle crossing into Canada as follows: "In the spring the Detroit river was literally swarming with the beetles and they were crossing Lake Erie on ships, chips, staves, boards, or any other floating object which presented itself. They soon infested all the islands to the west of the lake and by June were common around London, and finally occupied the whole country between the St. Clair and Niagara rivers." From its point of origin in North America, supposedly along the eastern slopes of the Rocky Mountains in the United States, the beetle has now been reported from every province in Canada except Newfoundland. To date, the northern limits of the species appear to be about Edmonton, Alberta, in the west and the northern boundary of New Brunswick in the east.

CONCLUSION

Not only should the entomologist concern himself with the obvious fact that faunal ranges are forever changing—either expanding or contracting, but seldom static—but he should also search for the reasons to account for them. Immense power of adaptation in living organisms must play an important part in the gradual changes that take place; the rapid changes are more difficult to comprehend with our present knowledge of biology. Our understanding of insect behavior will remain incomplete until adequate explanations are forthcoming. Here is one of the real challenges in entomology.

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THE RATIONALE OF INSECTICIDE INVESTIGATIONS AND AN ANNOTATED LIST OF COMPOUNDS TESTED FOR INSECTICIDAL AND PHYTOCIDAL POTENCY DURING 1956.[1]

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INTRODUCTION

The work on the hormones regulating metamorphosis in insects is attracting considerable attention at the present time. This work, which seems to have begun several decades ago in Europe (7) has now reached the stage where it seems possible that the structural formulae of the hormones will be known before long; and it has been predicted that they may be the insecticides of the future. This is a fascinating possibility. But it is a big step from the discovery of the existence of a hormone to its isolation. Indeed, it has taken twenty years and several pounds of insects. It is a bigger step to the production of the hormones in sufficient quantity at cost reasonable enough to compete with existing insecticides. This assumes that quantity production will be possible and that the materials will be suitable for field application and will be sufficiently free of human health hazard to permit their general use.

[1] No. 5 in a series of papers.

Meanwhile good insecticides are needed, and there is still no method of prophesying which compound will be the perfect insecticide.

It is with these ideas in mind that we have thought it proper to continue a search for cheap and effective chemicals for insect control. At present, we are continuing with old established methods while keeping in mind the stimuli to rational thinking about insecticides that certain recent findings are giving us: for example, the work on growth and metamorphosis (3); the investigations on resistance development (1); and the ideas on cuticular penetration by molecules of specific configuration (4).

We therefore feel that it is of both academic and practical benefit to many kinds of investigators (e.g. those interested in insecticides, herbicides, physiology, pharmacology and aphidology) to publish an annotated list of the results of screening operations during the last year (ending Dec. 31, 1956).

DETAILS

Two hundred and fifty eight compounds were investigated for insecticidal action against two species of aphids and for phytotoxic effect.

There have been no significant changes in our technique (5). Most compounds were tested initially as 1% concentrations in our standard benzene emulsion but about 25% of them (chiefly organo-phosphorus compounds) were tested as acetone solutions. One compound was investigated for systemic action by the methods previously described (5). Results are given below. Most of the compounds were prepared by Drs. M. Kulka and F. Stryk of Dominion Rubber Company. (2).

RESULTS

All compounds are listed in Table I.

Two compounds of particular interest were submitted. It is thought possible that one of them was part of a complex. The mixture was, however, crude and more than the following three compounds may have been present:

i) ethyl metaphosphate, which is already known as an insecticide.
ii) ethyl thiocyanate.
iii) diethyl phosphorothiocyanitidate.

Of these (iii) was particularly interesting, as it was possible to compare its performance with another and related compound (iv) dibutyl phosphorothiocyanitidate. These two compounds both showed considerable promise as insecticides; the diethyl compound was effective as both a direct spray and a residual deposit, whereas the dibutyl compound was very toxic as a direct spray but less toxic as a residual deposit. These results are interesting as one might expect the higher boiling point compound, the dibutyl, to be less volatile and therefore more persistent.

A third highly toxic compound (tetraethyl pyrophosphate) has also recently been investigated (See Table I, compound No. 195).

The following compounds and mixtures were promisingly (95% mortality and up) toxic to both species.

A. By Direct Spray:
No. 113 Dichloropropyl* lauryl sulfite

*Mixed isomers

No. 122 O,O-Diisopropyl-O,O-diethyl dithiopyrophosphate
No. 193 O,O-Diethyl phosphorothiocyanatidate
No. 195 Tetraethyl thiopyrophosphate
No. 201 O,O-Dibutyl phosphorothiocyanatidate

B. As Residual Deposits:

No. 1 p p-Chlorophenyl 4-chlorobutyl ether
No. 21 p-Chlorophenyl 3-bromopropyl sulfide
No. 22 p-Chlorophenyl 2-bromoethyl sulfide
No. 103 O,O-Dimethyl 2,2,2-trichloro-1-hydroxyethyl phosphate
No. 140 O,O-Diethyl thiocyanophosphate
No. 141 O,O-Diethyl chlorothiophosphate
No. 193 O,O-Diethyl phosphorothiocyanatidate
No. 195 Tetraethyl thiopyrophosphate

The following compound was significantly toxic by direct spray to *Sitophilus granarius, Sitophilus oryza* and *Tribolium confusum*:
No. 193 O,O-Diethyl phosphorothiocyanatidate

Investigation of the compound
No. 139 2-fluoro-1'2'2'2'-tetrachlorodiethyl ether (6).

This compound was tested over a period of two months. It was tested as a direct spray and as a residual deposit by our standard method (5). At 0.1% in acetone it was not toxic. (See Table I under Miscellaneous Compounds.) When tested as a systemic poison using our previously described methods (5) it was not effective painted on leaves of plants nor when seeds were soaked in it; but bean plants that received a root application of three treatments of 20 ml. of 0.001% concentration applied at 48 hour intervals were toxic to *Aphis fabae* and *Macrosiphum pisi*. Four days after being placed on each of three treated plants all *A. fabae* were dead; of the 59 *M. pisi* placed on three similar plants 21 were moribund and 38 were dead. No mortality was observed in either of the two checks.

Phytotoxicity

In the formulations used, many of the compounds were found to be phytotoxic. This may have resulted, in part, from the benzene emulsion or other carrier used, and the compounds might be less phytotoxic if formulated differently. However, it is worth noting that the following compounds were found by us to be markedly phytotoxic and, in consequence, may have value in weed control or other herbicidal formulations.

No. 3 3-p-Chlorophenoxypropyl mercaptan
No. 8 N-Benzoyl piperidine
No. 18 4-p-Chlorophenxy-2-butenyl bromide
No. 22 p-Chlorophenyl 2-bromoethyl sulfide
No. 75 2,3,4,4,5,6-Hexachloro-1,4-benzoquinone
No. 114 bis-(p-Chlorophenyl) hydrogen phosphite
No. 128 3-Methylindazole
No. 841 4-Chlorodiphenylmethane
No. 844 αβ-Methyl naphthyl ether
No. 855 Benzoyl piperidine

ACKNOWLEDGMENTS

We should like to express our appreciation to Dr. W. E. Heming, Head, Department of Entomology and Zoology, O.A.C. and Dr. R. H. Manske,

Director of Research, Dominion Rubber Co., Guelph, whose interest and support made the present investigations possible.

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TABLE 1

Compounds are listed by chemical classification. The sample number is given in the left hand column as a convenient reference. The compounds were formulated as 1% in benzene emulsion (5) unless otherwise stated.

Mortilities in the controls were vary rarely more than 15%—usually less.

To the right of each compound are listed consecutively:—

i) its phytotoxicity as *yes*, yes, no or slight;
ii) its effect as a direct spray on *M. pisi*;
iii) its effect as a direct spray on *A. fabae;*
iv) its effect as a residual deposit on *M. pisi;*
v) its effect as a residual deposit on *A. fabae*.

O—indicates less than 70% mortality—assessed as non-insecticidal;

F—indicates 70%-94% mortality—assessed as slightly insecticidal;

T—indicates 95%-100% mortality—assessed as insecticidal or promising.

Thus, yes O F O T — indicates a compound to be phytotoxic, non-toxic to *M. pisi* by direct spray, slightly toxic to *A. fabae* as a direct spray, non-toxic to *M. pisi* as a residual insecticide and toxic to *A. fabae* as a residual insecticide.

Assessments marked * were made from means. All others from single tests.

No.	Name	i	ii	iii	iv	v
	Sulphides					
198	p-Chlorophenyl 4-chlorobutyl sulfide	Yes	O	F	O	F
126	p-Chlorobenzyl 2-thienyl sulfide	Yes	O	O	O	O
90	p-bis-(2-Chloroethylamino) 2-chloroethyl sulfide	Yes	O	O	O	O
55	p-Chlorophenyl 3-bromopropyl sulfide and p-chloro phenyl 2-thiocyanoethyl sulfide (mixed)	*Yes*	T	F	O	T
36	p-Chlorophenyl 2-bromoethylsulfide (0.5% benzene emulsion)	Yes	O	O	O	O
31	4-p-Chlorophenoxybutyl 2-thiocyanatoethyl sulfide	Sl	F	F	O	O
24	4-p-Chlorophenoxybutyl 2-chloroethyl sulfide	Yes	O	F	O	O
22	p-Chlorophenyl 2-bromoethyl sulfide	*Yes*	O	O	T	T
21	p-Chlorophenyl 3-bromopropyl sulfide	Yes	O	F	T	T
15	p-Chlorophenyl 2,3-dichloropropyl sulfide	Yes	O	O	O	O
13	p-Chlorophenyl 3-chloropropyl sulfide	Yes	O	O	F	T
4	n-Dodecyl p-chlorobenzyl sulfide	Sl	O	O	O	O
857	3-p-Chlorophenoxypropyl p-chlorobenzyl sulfide	Sl	F	F	O	O

No.	Name	i	ii	iii	iv	v
830	p-Chlorobenzyl 2-p-t-butylphenoxyethyl sulfide	Yes	O	O	O	O
828	p-Chlorophenyl 3-chloropropyl sulfide	No	O	O	O	O
209	p-Chlorophenyl 2-methoxyethyl sulfide	Yes	O	O	F	T
	Chlorides					
208	2-β-Chloroethylmercapto-5-chlorobenzyl chloride	Yes	O	O	O	O
207	2-β-Chloroethylmercapto-5-chlorobenzyl isothiuronium chloride (in 50% acetone)	No	O	O	O	O
169	N-p-Chlorobenzyl N,N-bis (2-chloroethyl) amine hydrochloride (in 50% acetone)	Yes	O	O	O	O
99	2-(3-Chloropropoxy)-5-chlorobenzyl chloride	Sl	O	O	O	O
76	3-p-t-Butyl phenoxypropyl chloride	Sl	O	O	O	O
67	2-(3-Chloro-2-hydroxypropoxy)-5-chloro-benzyl chloride	Sl	O	O	O	O
66	2-(4-Chlorobutoxy)-5-chlorobenzyl chloride	Yes	O	O	O	O
65	2-(4-Chlorobutoxyl)-5-t-butylbenzyl chloride	Yes	O	O	O	O
59	2-(3-Chloropropoxy)-5-t-butylbenzyl chloride	Yes	O	O	O	O
52	2-(4-Chlorobutoxy)-5-methylbenzyl chloride	Yes	O	O	O	O
48	p-Phenylphenacyl chloride (in 80% acetone)	No	O	O	O	O
44	4-p-Tolyloxybutyl chloride	Yes	O	O	O	F
23	Benzyltriethylammonium chloride (in water)	No	O	O	O	O
	Bromides					
854	Pentamethylene bromide	No	O	O	O	O
860	3-p-Chlorophenoxypropyl bromide	Yes	O*	O*	T*	F*
115	n-Butyl bromide	Yes	O	O	O	—
18	4-p-Chlorophenoxy-2-butenyl bromide	Yes	O	F	F	F
35	n-Tetradecyl bromide	Sl	O	O	T	O
29	n-Hexadecyl bromide	Yes	O	O	O	O
	Ethers					
105	p-Chlorophenyl 3-chloropropyl ether	Yes	O	—	O	—
42	α-Naphthyl 3-chloropropyl ether	Yes	O	O	O	O
41	α-Naphthyl 3-bromopropyl ether	Yes	O	O	O	O
10	3-Chloro-2-butenyl p-chlorophenyl ether	Yes	O	O	O	O
1	p-Chlorophenyl 4-chlorobutyl ether	Yes	O	O	T	F
844	α-Methyl naphthyl ether	Yes	O	O	O	F
	Phosphates					
847	Tributyl phosphate	Yes	O	O	—	—
45	O-Ethyl bis-p-chlorobenzyl trithiophosphate	Yes	O	O	O	O
91	Potassium diisopropyl dithiophosphate (in water)	Yes	O	O	O	O
103	O,O-Dimethyl 2,2,2-trichloro-1-hydroxyethyl phosphate	No	O	O	T	T
110	O,O-Diphenyl 2,2,2-trichloro-1-hydroxyethyl phosphate	Sl	O	—	O	—
120	O,O-Dibutyl 2,2,2-trichloro-1-hydroxyethyl phosphate	Yes	T*	O*	O*	—
116	Tricresyl phosphate	Yes	O	O	O	—
124	O,O-Diethyl chloro phosphate	Yes	O	O	O	O
122	O,O-Diisopropyl-O,O-diethyl dithiopyro phosphate	Yes	T*	T*	T	—
132	O,O-Diisopropyl-S-p-chlorobenzyl thiophosphate	Yes	O	F	O	O
134	Dimethylaminodichloro phosphate	Yes	O	O	O	O
138	Potassium O,O-diethylthiophosphate	No	O	O	O	O
140	O,O-Diethylthiocyanato thiophosphate	Yes	T	O	T	T
141	O,O-Diethylchloro thiophosphate	Yes	T*	F*	T	T
147	Ethoxydichloro thiophosphate	Yes	O	O	O	O
148	O,O,O-Triethyl thiophosphate	Sl	O	O	O	O
149	2-Chloroethyl dichlorothiophosphate	Yes	O	O	O	O
156	β-Chloroethoxy dichloro thiophosphate	Yes	O	—	O	—
157	O-Ethyldithiocyanato thiophosphate (in acetone)	No	O	T	F	O
168	O-Butyldichloro thiophosphate	Yes	F	O	O	O
177	O-Chloroethyl- O,O-diethyl phosphate	Yes	O	O	O	O
178	O-n-Propyldichloro thiophosphate	Yes	O	O	O	O
188	Diethyl phosphate (in 50% acetone)	No	O	F	O	O
194	Triethyl phosphate (in acetone)	No	O	O	O	O
195	Tetraethyl thiopyrophosphate (in acetone and in benzene emulsions)	Sl	T*	T*	T*	T*
204	O,O-Diethyl-O-2-thiocyanatoethyl phosphate	No	O	O	O	O

No.	Name	i	ii	iii	iv	v
	Phosphonates					
133	O,O-Diethyl-2-bromoethylphosphonate	No	O	O	O	O
193	O,O-Diethyl phosphorothiocyanatidate (in acetone)	Yes	T*	T*	T*	T*
201	O,O-Dibutyl phosphorothiocyanatidate (in acetone)	Yes	T*	T*	O*	O*
202	di-2-Chloroethyl chlorophosphonate	Yes	O	O	O	O
203	O,O-Diethyl-2-thiocyanoethylphosphonate (in acetone and in benzene emulsion)	No	O	O	O	O
213	di-2-Chloroethyl thiocyanato phosphonate	No	O	O	O	O
	Phosphites					
102	tri-p-Chlorophenyl phosphite	Yes	O	O	O	O
98	Dimethyl hydrogen phosphite	Sl	O	O	O	O
97	Dibutyl phosphite	Sl	O	O	O	O
108	Diphenyl hydrogen phosphite	Sl	O	—	O	—
114	bis-(p-Chlorophenyl) hydrogen phosphite	Yes	O	O	O	—
121	Triethyl phosphite	Yes	O	O	O	—
146	tris (2-Chloroethyl) phosphite	Yes	O	O	O	O
214	2-Ethylhexyl octylphenyl phosphite (in acetone)	No	O	O	O	O
	Carbamates					
183	p-Chlorophenyl dicyclopropylmethyl N,N-dimethyldithiocarbamate	No	O	O	O	O
173	Sodium N-methyl N-p-chlorobenzyl dithiocarbamate (in water)	No	O	O	O	O
152	Sodium N-benzyl-N-cyanoethyl dithiocarbamate (in water)	No	O	O	O	O
150	2-Thienyl N-benzyl-N-cyanoethyl dithiocarbamate	No	O	—	O	O
144	Chlorinated 2-thienyl N,N-dimethyldithiocarbamate	Yes	O	O	O	O
143	2-Thienyl N-methyl-N-p-chlorobenzyldithiocarbamate	No	O	O	O	O
130	2-Thienyl N,N-dimethyldithiocarbamate	Yes	F	T	O	O
32	Hexadecyl N,N-dimethyldithiocarbamate	No	O	O	O	O
30	p-Chlorophenylmercaptoethyl N,N-dimethyl-dithiocarbamate	No	O	O	O	O
26	n-Dodecyl N,N-dimethyldithiocarbamate	Sl	O	O	O	O
12	2,4-Dimethylbenzyl N,N-dimethyldithiocarbamate	Sl	O	O	O	O
11	n-Hexyl N,N-dimethyldithiocarbamate	Yes	O	O	O	O
859	4-p-Chlorophenoxybutyl N,N-dimethyldithiocarbamate	No	O	O	O	O
853	2-N,N-Dimethyldithiocarbamatoethoxy-5-methyl benzyl N,N-dimethyldithiocarbamate	No	O	O	O	O
852	2-Benzyloxyethyl N,N-dimethyldithiocarbamate	Sl	O	O	O	O
851	3-p-Chlorophenoxypropyl N,N-dimethyldithiocarbamate	No	O	O	O	O
850	2-p-Chlorophenoxyethyl N,N-dimethyldithiocarbamate	Sl	O	O	O	O
848	2-t-Butyl-4-methylphenoxyethyl N,N-dimethyl-dithiocarbamate	Yes	O	O	O	O
840	2,4-dichlorophenoxyethyl N,N-dimethyldithiocarbamate	No	O	O	O	O
839	Phenethyl N,N-dimethyldithiocarbamate	Sl	O	O	O	O
834	p-Chlorobenzylmercaptoethyl N,N-dimethyldithio-carbamate	Sl	O	O	O	O
833	3,4-Dichlorobenzyl N,N-dimethyldithiocarbamate	No	O	O	O	O
832	2,4-Dichlorobenzyl N,N-dimethyldithiocarbamate	No	O	O	O	O
831	2-p-Tolyloxyethyl N,N-dimethyldithiocarbamate	Sl	O	O	O	O
829	3-Nitro-4-methoxybenzyl N,N-dimethyldithiocarbamate	No	O	O	O	O
822	Benzyl N,N-dimethyldithiocarbamate	Yes	O	O	O	O
	Butanes					
212	1,4-bis-(p-Chlorophenylmercapto) butane	No	O	O	O	O
94	1,4-bis-p-Tolyloxybutane	Sl	O	O	O	O
93	1,4-bis-t-Butylphenoxy butane	No	O	O	O	O
54	1,1,1,3-Tetrachlorobutane	No	O	O	O	O
20	1,4-bis-p-Chlorophenoxybutane (in acetone)	No	O	O	O	O
17	1,4-bis-p-Chlorophenoxy-2-butene	No	O	O	O	O
842	2,3-bis-p-Chlorobenzylmercapto-1,4-dithiocyanatobutane	No	O	O	O	O
824	1,4-bis (p-Chlorophenylmercapto) butane	No	O	O	O	O
217	1,3-bis (p-Chlorophenylmercapto)-2-thiocyanatopropane	Sl	O	O	O	O

No.	Name	i	ii	iii	iv	v
	Propanes					
216	1,3-bis (p-Chlorophenylmercapto)-2-chloropropane	Yes	O	O	O	O
84	1,1,1-Trichloro-2-hydroxy-3-phenyl-3-cyanopropane	No	O	O	O	O
58	1,3-bis-p-t -Butylphenoxypropane	Sl	O	O	O	O
16	bis (p-Chlorophenylmercapto) 2-thiocyanopropane	No	O	O	O	O
14	bis- (p-Chlorophenylmercapto) 2-chloropropane	No	O	O	O	O
6	1,2,3-Trichloropropane	No	O	O	O	O
864	1,3-Dichloro-2-hydroxypropane	Sl	O	O	O	O
863	p,p'-bis (1,3-Chlorophenylmercapto)-2-hydroxy propane	No	O	O	O	O
858	1,3-bis-p-Chlorophenoxypropane	No	O	O	O	O
843	bis (p-Chlorobenzyimercapto) propane	Sl	T	F	O	O
826	1,3-Dichloropropane	Sl	O	O	O	O
823	1,2,3-tris-p-Chlorobenzylmercaptopropane	Yes	O	O	O	O
	Oxathiocins					
73	8-Chloro-3-hydroxy-2,3-dihydrobenzo (g)-1,5-oxathiocin	No	O	O	O	O
80	3,8-Dichloro-2,3-dihydrobenzo (g)-1,5-oxathiocin	Sl	O	O	O	O
87	3-Mercapto-8-chloro-2,3-dihydrobenzo (g)-1,5-oxathiocin	Sl	O	F	O	O
100	3-Bromo-8-chloro-2,3-dihydrobenzo (g)-1,5-oxathiocin	Yes	O	O	O	O
81	3-Thiocyanato-8-chloro-2,3-dihydrobenzo (g)-1,5-oxathiocin	No	T*	F*	O	O
82	3- (N,N-Dimethyldithiocarbamato)-8-chloro-2,3-dihydrobenzo (g)-1,5-oxathiocin	No	O	O	O	O
88	8-t-Butyl-2,3-dihydrobenzo (g)-1,5-oxathiocin	Yes	O	O	O	O
	Cyclohexanones					
153	2-p-Chlorophenylmercaptocyclohexanone	Yes	O	—	O	—
154	2-Chlorocyclohexanone	No	O	—	O	—
185	p-Chlorobenzalcyclohexanone	Yes	O	O	O	O
187	2,6-bis-p-chlorobenzalcyclohexanone (in acetone)	Crystalized in nozzle				
186	2-Benzalcyclohexanone	Yes	O	O	O	O
	Amines					
151	bis-p-Chlorobenzyl methylamine	Yes	T	—	O	O
155	N-2-Cyanoethyl-N-benzylamine	No	O	—	O	—
161	N- (2-Chloro-2-butenyl) N- (2-cyanoethyl) benzylamine	Yes	O	—	O	—
164	N-3,4-Dichlorobenzyl N,N-bis-p-chlorobenzylamine	No	O	O	O	O
170	N-p-Chlorobenzyl N,N-bis (2-thiocyanatoethyl) amine (Irritates mucus membranes)	No	O	O	O	T
172	N-p-Chlorobenzyl diethanolamine (in 70% acetone)	No	O	O	O	O
175	N,N-bis-p-Chlorobenzyl N-2-chloroethylamine	Yes	O	O	O	O
174	N,N-bis-p-Chlorobenzyl ethanolamine (in 70% alcohol)	No	O	O	O	O
	Ethanols					
846	2-Thiocyanoethanol	No	O	O	O	O
837	2-Bromoethanol	No	O	O	O	O
827	2-Mercaptoethenol	Sl	O	O	O	O
	Mercaptans					
33	Hexadecyl mercaptan	Yes	O	O	O	O
25	n-Dodecyl mercaptan	Yes	O	O	O	O
3	3-p-Chlorophenoxypropyl mercaptan	*Yes*	O*	O*	F*	F*
2	4-p-Chlorophenoxybutyl mercaptan	Yes	O	O	T	O
	Thiocyanates					
200	Butyl thiocyanate	No	O	O	O	O
199	Ethyl thiocyanate	Sl	O	O	O	O
61	p-Chloroaniline thiocyanate (in 60% acetone)	No	O	O	O	O
60	o-Chloroaniline thiocyanate (in 60% acetone)	No	O	O	O	O
49	Phenyl isothiocyanate	No	O	O	O	O
9	3-p-Chlorophenoxypropyl thiocyanate	Yes	T	F	O	O
19	4-p-Chlorophenoxy-2-butenyl thiocyanate	Yes	O	F	O	O

No.	Name	i	ii	iii	iv	v
	Methanes					
165	bis (N-Methyl-N-2-pyridylamino) methane	Sl	O	O	O	O
131	bis (2-Thienyl) methane	Yes	O	O	O	O
856	Triphenylchloromethane	Not soluble				
841	4-Chlorodiphenylmethane	Yes	O	O	F	T
836	bis (p-Chlorobenzylmercapto) methane	No	O	O	O	O
	Ethanes					
107	1,1-bis-p-Chlorophenyl-1,2,2,2-tetrachloroethane (in 80% acetone)	No	O	—	O	—
101	1,1-bis-p-Chlorophenyl-2,2-dichloroethene	Sl	O	O	O	O
27	bis (p,p-Chlorophenylmercapto) ethane	Sl	O	O	O	O
835	bis (p-Chlorobenzylmercapto) ethane	No	O	O	O	O
	Pentanes					
862	1,5-Dibromopentane	No	O	O	O	O
53	1,1,1,5-Tetradichloropentane	No	O	O	O	O
7	bis (p-Chlorobenzylmercapto) pentane	Sl	O	O	O	O
861	1,5-bis (p-Chlorophenylmercapto) pentane	Sl	F	T	O	O
	Miscellaneous					
139	2-Fluoro-1',2',2'2'-tetrachlorodiethyl ether (0.1% in acetone)* (6).	No	O	O	O	O
		(Some systemic effect, see text)				
34	tris (1,1,1-Trichloro-2-methylpropyl) cyanurate (in 60% acetone)	No	O	O	O	O
838	tris (2-Hydroxyethylthio) cyanurate (in 40% acetone)	No	O	F	O	O
191	Polymeric thiocyanic acid (in acetone)	No	O	O	O	O
190	Thiocyanic acid (in acetone)	Sl	O	O	O	O
189	Thiocyanic acid (in water)	Yes	O	F	O	O
167	*w*-p-Chlorophenylsulfonylhexanoic acid (in 70% acetone)	No	O	O	O	O
117	2-Methylsulfonylmethyl-4-chlorophenoxyacetic acid (0.2% in 20% acetone)	No	O	O	O	—
104	Diphenylacetic acid	No	O	O	O	O
79	Benzilic acid	Yes	O	O	O	O
846	Cyanuric acid (in 60% acetone)	No	O	O	O	O
179	3,4-Dihydrocarbostyril (in 70% acetone)	No	O	O	O	O
184	Dichlorodihydrocarbostyril (in acetone)	No	O	O	O	O
211	1,3-bis- (p-Chlorophenylmercapto)-2-propanol	No	O	O	O	O
28	1,1,1-Trichloro-2-methyl-2-propanol	No	O	O	O	O
63	o-Chloroaniline	No	O	O	O	O
62	p-Chloroaniline	No	O	O	O	O
129	3-Phenyl-3-triazolo (f) quinoline	Yes	O	O	O	O
137	2-Methyl-4-p-chlorobenzylmercapto-6-chloroquinoline	Sl	O	O	O	O
46	2-Hydroxymethyl-4,5-dihydroxy-4-cyano-1,4-pyran (in water)	No	O	O	O	O
39	2-p-Chlorophenylmercaptomethyl-4-cyano-4,5-dihydroxy-1,4-pyran (in 70% acetone)	No	O	O	O	O
112	Isopropylphenyl tridecyl sulfite	Yes	O	F	O	—
113	Dichloropropyl lauryl sulfite (mixed isomers)	Yes	T*	T*	O	—
89	9-t-Butyl-2,3,4,5-tetrahydrobenzo (h)-1,6-oxathionine	Yes	O	O	O	O
83	9-Chloro-2,3,4,5-tetrahydrobenzo (h)-1,6-oxathionine	Yes	O	O	O	O
77	bis (Cyanocrotenyl) hydrazine	No	O	O	O	O
69	Symm. bis (1-Cyanocyclohexyl) hydrazine	No	O	O	O	O
68	bis (Thiocyanoisopropyl) hydrazine	No	O	O	O	O
47	bis (Cyanoisopropyl) hydrazine	No	O	O	O*	F*
92	Diphenylene oxide	Sl	O	O	O	F
106	3-Oxo-8-chloro-2,3-dihydrobenzo (g)-1,5-oxathiocin-5,5-dioxide (in 70% acetone)	No	O	—	O	—
74	9-Methyl-2,3,4,5-tetrahydrobenzo (h)-1,6-oxathionine-4,4-dioxide (in 50% acetone)	No	O	O	O	O
64	8-t-Butyl-2,3-dihydro-1,5-oxathionine-5,5-dioxide	Yes	O	O	O	O
118	p-Chlorobenzyloxy acetonitrile	Yes	O	O	T	—

* See page 21.

No.	Name	i	ii	iii	iv	v
86	1,2-Azo-bis-α, α,-isobutyronitrile	Sl	O	O	O	O
125	Methyl β-benzoylpropionate	Sl	O	O	O	O
127	4,4'-Dichlorobenzophenone hydrazone	Yes	T	O	O	O
135	1,2,3,4-Tetrahydro-6-carboxyethylcarbazole (in 70% acetone)	No	O	O	O	O
128	3-Methylindazole	*Yes*	O	O	O	O
159	1-Phenyl-5-aminobenzotriazole (in acetone)	No	O	—	O	—
95	3-Hydrazino-4-amino-5-mercapto-4,1,2-triazole (O.1N HCl)	Sl	O	O	O	O
37	2-Chloromethyl-4-cyano-4,5-dihydroxy-1,4-pyran (in 70% acetone)	No	O	O	O	O
38	2-Dimethyldithiocarbamatomethyl-4-cyano-4,5-dihydroxy-1,4-pyran (in 70% acetone)	No	O	O	O	O
855	Benzoylpiperidine	*Yes*	O	O	O	O
5	bis (p-Chlorophenyl mercapto) propane and diperonyl butoxide	Sl	T	T	O	O
181	4-p-Hydroxyphenyl-2,2,4-trimethylchroman	No	O	O	O	O
206	7-Chloro-2,3-dihydro-1,4-dithiepin	Yes	O	O	O	O
160	2-Cyclohexanonyl p-chlorophenyl sulfone (in 50% acetone)	No	O	—	O	—
109	2,8-Dichlorodibenzofuran (in 90% acetone)	Yes	O	—	O	—
43	tert.-Butylbenzene	Sl	O	O	O	O
205	2,6-Diiodo-p-nitroanisole	No	O	O	O	O
171	2-Chloroethyl coumalate	Yes	O	O	O	O
182	Dicyclopropyl ketone	No	O	O	O	O
166	2,4-Dichlorobenzyl chloride (quaternary salt) and hexamethylenetetramine (in water)	No	O	O	O	O
163	Semicarbazone of ethyl pyruvate (in acetone)	Crystalized				
162	di-2-Chloroethyl α,β-dichloropropionaldehyde acetal	Yes	O	—	O	—
136	β- (N,N-Dimethyldithiocarbamato)-α-chloro-propionaldehyde	No	O	O	O	O
8	N-Benzoyl piperidine	*Yes*	O	O	O	O
180	Dicyclopropyl p-chlorophenylcarbinol	No	O	O	O	O
218	1,3-bis (p-Chlorophenylmercapto)-2-propanone	No	O	O	O	O
85	2-Aminobenzenethiol	Yes	O	O	O	O
78	Ethyl azodicarboxylate	No	O	O	O	O
72	Ethyl 1,2-hydrazindicarboxylate (in 60% acetone)	No	O	O	O	O
71	1,1'-Dicyanodicyclohexyl	No	O	O	O	O
40	4-Phenyl-1,2-dithiole-3-thione (in acetone)	No	O	O	O	O
50	Dicyclohexylmethane-2,2'-dione	Yes	O	O	O	O
176	1,7-Dichloro-4-heptanone	Yes	O	O	O	O
75	2,3,4,4,5,6-Hexachloro-1,4-benzoquinone	*Yes*	O	O	O	O
111	bis (1,2,3,4,5-Pentachlorocyclopentadienyl)	Yes	O	F	O	—
96	Hexamethyl phosphoramide	Sl	O	O	O	O
849	Benzothiazolyl N'-t-butyl sulfenamide	Yes	O	O	O	O
119	p-Chlorobenzyloxyacetamide (in 50% acetone)	No	O	O	O	—
70	Symm. Azo-bis (1-cyanocyclohexane)	No	O	O	O	O
825	1,5-Pentanediol	No	O	O	O	O

SOME TABANIDAE (DIPTERA) NOT PREVIOUSLY RECORDED FROM CANADA

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None of the following species of Tabanidae seems to have been definitely recorded from Canada, heretofore. I wish to record the following.

PANGONIINAE

Apatolestes villosulus (Bigot). Robson, British Columbia, ♀, 26 July 1956; ♀, 12 August 1955; ♂, 10 September 1955 (all H. R. Foxlee).

Goniops chrysocoma (O.S.). Grimsby, Ontario, ♀ (J. Pettit).

CHRYSOPINAE

Merycomyia whitneyi (Johnson). Hamilton, Ontario, ♂, 4 August 1947 (W. Judd). This species is rarely collected.

Chrysops carbonaria nubiapex Philip. Hamilton, Ontario, ♂, 2 June 1933; Brampton, Ontario, ♂, 9 June 1953 (G. B. Wiggins); Cochrane, Ontario, ♀, 9 July 1953 (L. L. P.); Sturgeon Lake, Thunder Bay District, Ontario, ♀, 24 July 1954.

Chrysops pikei Whitney. Chatham, Ontario, ♀, 20 July (W. Judd). This is a midwestern form which is expanding its range eastward. It is now found in Western New York and probably is present in a number of localities in southern Ontario.

Chrysops univittata Macquart. Puslinch, Ontario, ♀, 24 June 1952 (L. L. P.).

TABANINAE

Tabanus (Hybomitra) affinis aurilimbus Stone. Bigwood, Ontario, ♀, 20 July 1955 (L. L. P.). This subspecies has a more southern distribution than the typical form and its appearance in this locality is somewhat unexpected. However, of two other species of *Tabanus* with southern affinities, *T. sagax* is reported from this locality and *T. nigripes* from the same general area.

Tabanus (Hybomitra) zygotus Philip. Robson, British Columbia, ♀, 11 August 1953; ♀, 23 August 1955; ♀, 19 July 1956 (all H. R. Foxlee); Kaslo, British Columbia, ♀, 15 August (A. N. Caudell). This species has been reported only from Washington and Oregon.

Tabanus (Tabanus) nigripes Wied. Bonsoleid Isl., Georgian Bay, Ontario, ♀, 28 July 1924 (S. Thompson); Orrville, Ontario, ♀, 7 July 1956 (L. L. P.); ♀, 21 July 1955 (L. L. P.); Key River, Ontario, ♀, 20 July 1955 (L. L. P.).

Tabanus (Tabanus) sagax O. S. Bigwood, Ontario, ♀, 20 July 1955 (L. L. P.).

Tabanus (Tabanus) subniger Coquillett. Erindale, Ontario, ♂, 16 June 1932 (F. P. Ide). This species is rare in collections.

Tabanus (Tabanus) sulcifrons Macquart. Toronto, Ontario, ♀, 30 July 1933 (F. A. Urquhart). It is somewhat surprising that no other specimens of this species from Canada have been seen. It is common along the United States' side of the Niagara River and it should be present throughout the Niagara Peninsula.

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FURTHER LABORATORY AND FIELD OBSERVATIONS ON THE ECOLOGY OF SOME ONTARIO CUTEREBRIDAE (DIPTERA), IN PARTICULAR, *CUTEREBRA ANGUSTIFRONS* DALMAT 1942

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INTRODUCTION.

This paper extends previously reported observations (15) on a cuterebrid larva infesting the northern white-footed mouse, *Peromyscus leucopus noveboracensis,* in southern Ontario and elsewhere in the range of this host (eastern

North America). A description of the methods of live-trapping, examining and maintaining the hosts and larval and pupal stages of the parasite has already been given (15).

Seventy larvae were found infesting *P. leucopus* during the 1955 season, but only 49 larvae successfully formed puparia. The remaining 21 larvae were lost, so far as further development was concerned, for a variety of reasons: the larvae died *in situ,* or were eaten by the mice as the larvae matured and left their cavities, or were preserved for the record, and so forth.

Of the 49 larvae which formed puparia, only 31 adults successfully emerged. In 18 instances, adults failed to emerge because (a) no pupa formed; or (b) the pupae died at various times during the long pupal period; or (c) accidental death occurred.

THE SPECIES OF *CUTEREBRA* IN ONTARIO

Identification of the species under consideration was made possible by examination of and comparison with reared and wild-caught adults in collections of the United States National Museum, the University of Michigan Museum of Zoology, and of Drs. Henry Townes and Lawrence R. Penner. Dr. Curtis W. Sabrosky, Insect Identification and Parasite Introduction Section, Entomology Research Branch, United States Department of Agriculture, was very helpful with advice and orientation.

All except one of the flies under study were identified as *Cuterebra angustifrons* Dalmat 1942, though flies reared from larvae infesting the white-footed mouse have previously been identified as *C. fontinella* Clark (e.g., Penner and Pocius (13), Greene (7), Johnson (8)). *C. fontinella* was originally described from Illinois, as infesting "rabbits" (3). Unfortunately the exact names of the host or hosts were not definitely recorded at that time. Townsend (17) obtained two cuterebrid larvae from two cottontails in New Mexico, and described the females he reared from them. He considered them to be *C. fontinella* Clark. A fly reared from a larva infesting *Mus musculus* was identified by Sabrosky at the time as *C. fontinella* Clark "complex" (9). Flies which may be similar to those reared from the white-footed mouse, have been reared from larvae infesting *Rattus norvegicus, Rattus rattus,* and *Eutamias* sp. Thus there are questions both of the true application of the name and of the number of species in the "*fontinella* complex". Until these questions can be satisfactorily elucidated, I believe it better to use the name *C. angustifrons* for my material, the type of that species being available (on deposit in the United States National Museum), and being clearly conspecific with the Ontario material.

Swenk (16), in his key to the North American species of *Cuterebra,* initially partitioned them into two groups: (a) those with yellow pubescence on the dorsum of the thorax, and (b) those with black. It is possible to identify tentatively the species of *Cuterebra* occurring in Ontario by noting first the colour of the pubescence on the thorax, and then size, host relationship, and certain other characters. In each of the above groups there are forms larger and smaller than 20 millimeters in length. For example, *Cuterebra horripilum,* a large form with dense yellowish pile on the thorax, infests rabbits in eastern North America. It has been reared from cottontails in Michigan, and at least one wild-caught specimen is in the collection of the Department of Entomology and Zoology, Ontario Agricultural College. *C. cuniculi,* likewise a large form infesting rabbits, is distinguished from *C. horripilum* by having a large rectangular black space in the middle of the thorax; comparatively little is known of its geographic distribution. *C. emasculator,* one of the small forms in the first group, infests chipmunks in northern Ontario. Its life history has been studied by Bennett (2).

C. grisea, another small form with yellow hairs on the mesonotum, is similar to *C. emasculator* in size and general appearance. However, abdominal segment V of *C. grisea* is clothed with yellow hairs, and is densely yellowish pollinose, whereas that of *C. emasculator* is shining. *C. grisea* is known to infest *Citellus* (ground squirrels) and *Eutamias* (western chipmunks) in western U.S. and Canada. Thus it is interesting to note that one specimen of *C. grisea* was reared among several *C. angustifrons* from larvae infesting a population of *P. leucopus* in one woodlot at Brantford, Ontario. The larva from which this specimen was reared was the only one infesting its host. This appears to be the first record of the rearing of *C. grisea* from a larva infesting the white-footed mouse in Canada, and the second in North America. Greene (7) reported on adults reared from larvae infesting *P. leucopus* in New Jersey. He identified them as *C. fontinella,* but Sabrosky has redetermined them; three adults are identical with *C. angustifrons* and one adult is *C. grisea.*

C. angustifrons is one of the small forms with black hairs on the thorax. Though it is of the same size and general appearance as *C. emasculator* and *C. grisea,* it can be differentiated from these forms by the colour of the hair on the mesonotum. Dalmat (4) described a second species, *C. peromysci,* from two adults which he reared from larvae infesting the northern white-footed mouse at Ames, Iowa, the type locality for *C. angustifrons.* It resembles *C. angustifrons* closely in general appearance and size. Dalmat (5) distinguished *C. angustifrons* from *C. peromysci* primarily on the basis of differences in shape of the prevertex and mesovertex. The series of specimens reared in this study show a range of variation in the shape of the prevertex which renders this character of no value in differentiating these two species. However, the type specimen of *C. peromysci* possesses distinct and heavy pollinose bands on the dorsal abdominal sclerites, and these are not found on the type specimen of *C. angustifrons* or any of the flies resembling that form, which I have seen. Pending further study, *C. peromysci* would apear to be a valid species.

The following species of *Cuterebra* are known to occur in Ontario, on the basis of life history studies and specimens of adults in collections: *C. angustifrons, C. grisea, C. emasculator,* and *C. horripilum.* While no records are yet established, the following species may occur in Ontario: *C. peromysci, C. buccata,* and *C. cuniculi.* It should be emphasized that certain identification of these species is made from adults and therefore every effort should be made to rear adults from larvae infesting various hosts.

METHODS.

Infested mice were live-trapped and taken to the laboratory. They were examined daily under a stereoscopic microscope. The instar of the larva was determined, and the molt from second to third instar confirmed, by inspection of the posterior stigmal plates.

As each larva matured and left its host, it was weighed, and set on moist sawdust in a glass jar to await puparium formation. Puparia were weighed as soon as possible after formation (a variable number of hours), and each day thereafter until the weight appeared to be constant, and then once each month until the adult emerged. The mean percentage weight loss of pupae during their development was computed from the initial puparial weight and the mean of the monthly series of constant weights. Weighings were carried out on a single-pan direct-reading, analytical balance.

Puparia were kept in moist sawdust. They were divided into three groups, each subjected to different temperature conditions: (a) room temperature (18° C. to 24° C.) for duration of pupal period; (b) room temperature for 67 to 90

days; refrigerator (7° C.) for 148 days; room temperature to emergence (30 to 48 days); and (c) temperatures approximating those during winter at about two to four inches beneath the soil. Puparia in the latter group were kept in an unheated building, inside a corrugated cardboard box surrounded by crumpled paper towelling. Temperatures were recorded three or four times each day. During the 18 midwinter weeks the temperature was two or three degrees above or below 0° C. This temperature record was comparable to that obtained at four and twelve inches under exposed sod at the Soils Department Hydrology Station in Guelph during the same winter (1955-1956), and, it is believed, represents temperature conditions equivalent to those experienced by puparia in nature.

As soon as they emerged adult flies were placed in quart mason jars with galvanized mesh tops. A strip of blotting paper provided a vertical support, since it was observed that the flies preferred a vertical position before expanding their wings. After 24 to 48 hours flies were placed in groups in wooden frame cages (1 x 1 x 2 feet) covered with fine gauze. To provide larger cages, these cages were joined together in pairs. Water, honey and strips of blotting paper were made available to the flies. Eggs were laid on the blotting paper which facilitated their collection and counting, as well as observations on oviposition.

OBSERVATIONS IN THE LABORATORY.

Development of larvae and pupae: Weights, measurements and other data for a series of larvae and pupae of *C. angustifrons* reared to adults are summarized in Table 1.

Table 1 shows: (a) female larvae (3rd instar) and pupae are heavier, and larger, than male larvae and pupae; and (b) there is a 15% weight loss during the first six days after formation of puparium, following which the weight remains constant.

TABLE 1. WEIGHTS AND DIMENSIONS OF THIRD INSTAR LARVAE AND PUPARIA

	THIRD STADIUM WEIGHT AT MATURITY	PUPARIAL WEIGHT AT TIME OF FORMATION	PUPARIAL DIMENSIONS	NUMBER OF DAYS FOR PUPARIA TO REACH CONSTANT WEIGHT	PERCENT WEIGHT LOSS, PUPARIA
♂	0.79 (0.58 to 1.03) (13)*	0.75 (0.59 to 0.85) (17)	17.3 x 9.5 x 9 (15.5 x 8.8 x 8 to 19 x 10 x 10) (17)	5.7 (4 to 7) (16)	15.2 (12 to 18) (16)
♀	0.90 (.75 to 1.06) (9)	0.92 (0.75 to 1.11) (11)	18.6 x 9.7 x 9.4 (17.5 x 9 x 9 to 20 x 10 x 10) (11)	7 (6 to 12) (11)	15.5 (14 to 18) (11)
Both Sexes	0.84 (0.57 to 1.06) (22)	0.82 (0.59 to 1.11) (28)	17.8 x 9.6 x 9.2 (15.5 x 8.8 x 8 to 20 x 10 x 10) (28)	6.2 (4 to 12) (27)	15.4 (12 to 18) (27)

Weights: Mean and Range in gms.

Dimensions: Mean and Range in mm. — Length x Width x Dorso-Ventral Thickness.

* Indicates number of specimens.

The length of the larval period is not known. Six days elapsed from the time of appearance of the opening in the skin of the host until the molt to third instar. In 16 instances the molt from the second to the third instar was observed within a few hours of its occurrence. The duration of the third stadium was 11 days, with a range of 10 to 14 days.

This period did not vary in length over September and October.

In two cases, part of the second instar exuvium containing the stigmal plates was observed at the opening of the 'warble' in the pelt of its host. The posterior stigmal plates were seen over the third instar larva at the opening of the 'warble'. Sometimes part of the second instar exuvium partially or completely plugged the air hole.

In Table 2 data on length of pupal period and percent of emergence of adults for each of the three groups of puparia maintained under different temperature conditions are given.

Three conclusions are arrived at from Table 2. The long pupal period, whatever the temperature to which the pupae were subjected, suggests that *C. angustifrons* possesses diapause in the pupal stage. It is interesting to note in this connection that a female (No. 8-55) emerged after 42 days at room temperature within its puparium. A period of exposure to cold temperatures, whatever its length, favours emergence of a greater percentage of adult flies. The duration of the pupal period of *C. angustifrons* averaged 315 days under temperature conditions aproximating those in nature. Since the numbers of puparia involved in these rearing experiments are small, conclusions are necessarily tentative.

TABLE 2. REARING OF *CUTEREBRA ANGUSTIFRONS*

NUMBER OF PUPARIA	TEMPERATURE CONDITIONS	DURATION OF PUPAL PERIOD IN DAYS (mean and range)	PERCENT (AND NUMBER) OF ADULTS EMERGED
13	Room temperature (18° C. to 24° C.)	216.8 (192 to 237)*	46% (6)
25	Room temperature (67 to 90 days); refrigerator (148 days), 7° C.; room temperature (30 to 48 days)	258.8 (245 to 274)	72% (18)
10	Temperatures approximating those at about two to four inches beneath the soil, during the winter.	315.4 (301 to 333)	70% (7)

* One pupal period of 42 days not included in this mean and range; see text.

Table 3 gives detailed information on the rearing of each adult. The following points are evident. In all groups there was an inverse relationship between the order in which puparia were formed and the order in which adults emerged. There was as well an inverse relationship between the length of the pupal period and date of formation of puparium, e.g., the pupal period of Specimen No. 42-55, which formed its puparium September 1, 1955, is 245 days, whereas the pupal period of Specimen No. 6-55, which formed its puparium three weeks before (August 8, 1955) is 274 days. Males generally emerged before females. Flies emerged within a few days of each other, and this period of emergence varied in length according to the temperature conditions under which pupae were maintained, i.e., flies in Group One emerged within a period of 43 days, flies in Group Two emerged in two separate groups over five to six days separated by an interval of nine days, and flies in Group Three emerged within a 25 day period. The more uniform emergence period of the flies in Group Two again suggests the probability of pupal diapause.

TABLE 3. REARING OF *C. ANGUSTIFRONS*

GROUP ONE—ROOM TEMPERATURE, 18° C. TO 24° C., FOR DURATION OF PUPAL PERIOD

PUPARIUM NUMBER	OBSERVED DURATION OF PUPAL PERIOD IN DAYS	DATE OF FORMATION OF PUPARIUM	DATE OF EMERGENCE OF ADULT	SEX
8-55	42	Aug. 8, '55	Sept. 19, '55	F
65-55	192	Sept. 24, '55	Apr. 3, '56	M
62-55	214	Sept. 20, '55	Apr. 21, '56	F
63-55	215	Sept. 21, '55	Apr. 23, '56	F
61-55	226	Sept. 20, '55	May 3, '56	F
64-55	237	Sept. 22, '55	May 16, '56	F

GROUP TWO—ROOM TEMPERATURE (67 TO 91 DAYS); REFRIGERATOR AT 7° C. (148 DAYS); ROOM TEMPERATURE (30 TO 48 DAYS)

PUPARIUM NUMBER	OBSERVED DURATION OF PUPAL PERIOD IN DAYS	DATE OF FORMATION OF PUPARIUM	DATE OF EMERGENCE OF ADULT	SEX	NUMBER OF DAYS TO EMERGENCE AFTER BRINGING TO ROOM TEMPERATURE
42-55	245	Sept. 1, '55	May 3, '56	M	30
40-55	246	Aug. 31, '55	May 3, '56	M	30
30-55	251	Aug. 27, '55	May 4, '56	M	31
28-55	253	Aug. 27, '55	May 6, '56	M	33
21-55	253	Aug. 25, '55	May 4, '56	M	31
24-55	255	Aug. 26, '55	May 7, '56	F	34
26-55	255	Aug. 26, '55	May 7, '56	F	34
16-55	258	Aug. 22, '55	May 6, '56	M	33
15-55	258	Aug. 20, '55	May 4, '56	M	31
12-55	259	Aug. 19, '55	May 4, '56	M	31
6-55	274	Aug. 8, '55	May 7, '56	M	34
41-55	259	Aug. 31, '55	May 16, '56	F	43
27-55	267	Aug. 27, '55	May 20, '56	M	47
34-55	268	Aug. 27, '55	May 21, '56	M	48
25-55	268	Aug. 26, '55	May 20, '56	F	47
18-55	268	Aug. 25, '55	May 19, '56	M	46
17-55	269	Aug. 23, '55	May 18, '56	M	45

GROUP THREE—TEMPERATURES APPROXIMATING THOSE AT ABOUT TWO TO FOUR INCHES BENEATH THE SOIL DURING THE WINTER, FOR DURATION OF PUPAL PERIOD

PUPARIUM NUMBER	OBSERVED DURATION OF PUPAL PERIOD IN DAYS	DATE OF FORMATION OF PUPARIUM	DATE OF EMERGENCE OF ADULT	SEX
53-55	301	Sept. 14, '55	July 9, '56	M
52-55	304	Sept. 12, '55	July 12, '56	F
48-55	307	Sept. 6, '55	July 9, '56	M
47-55	309	Sept. 6, '55	July 11, '56	F
44-55	324	Sept. 2, '55	July 22, '56	F
46-55	330	Sept. 4, '55	July 30, '56	F
45-55	333	Sept. 3, '55	Aug. 1, '56	M

It is interesting to note the two apparent "waves" of emergence of adults from puparia in Group Two (Table 2): (a) Twelve flies (nine males and three females) emerged within five days of one another, 30 to 34 days after removal from the refrigerator; and (b) six flies (four males and two females) emerged within six days of one another, 43 to 48 days after removal from the refrigerator. These two "waves" are thus separated by an interval of nine days. Possibly a larger number of specimens might have eliminated this discontinuity. Sex differences were probably not responsible for this phenomenon, since there was about an equal distribution of sexes among the two series. All the flies in Group Two were reared from larvae taken from mice distributed about equally among three woodlots, in Brantford and Guelph, so locality or latitude do not appear to be involved. Only two of the mice contributed larvae to both of these subgroups, so that it would appear that influence of hosts, and number of larvae developing in them, were not involved.

The adults: Flies emerged between 9 a.m. and 12 noon. They quickly pushed off the operculum, usually within thirty seconds. The ptilinum was a prominent feature of the newly emerged fly. The wings expanded usually within ten to twenty minutes of emergence, if the flies were permitted to climb onto a vertical support. Often during subsequent days, they assumed a position on vertical support, head down, and remained inactive for two or three hours. They were never observed to feed in the laboratory, but a copious discharge from the rectum was seen over four or five days after emergence. The flies were attracted to light. In containers of any size and type, and in dim or bright light, the flies were generally sluggish and clumsy, and rarely flew even when picked up and dropped.

Table 4 shows measurements of epicranial space (space between the eyes at the top of the head), ratio of head width at eyes to epicranial space, and length and width of eyes of males and females.

TABLE 4. MEASUREMENTS OF EPICRANIAL SPACE AND EYES OF ADULT *C. ANGUSTIFRONS*

SEX AND NUMBER MEASURED	EPICRANIAL SPACE	RATIO OF HEAD WIDTH TO EPICRANIAL SPACE	EYES	
			LENGTH	WIDTH
Male (15)	1.25* (1.1 to 1.5)	5.5 (4.7 to 6.2)	3.9 (3.7 to 4.1)	2.5 (2.4 to 2.7)
Female (13)	2.6 (2.4 to 2.9)	2.7 (2.6 to 3)	3.5 (3.3 to 3.8)	2.2 (2 to 2.5)

* Mean and range in millimeters.

The following points are evident from Table 4. In females the epicranial space was greater than in males. The ratio of head width at eyes to epicranial space likewise differed according to sex. A difference in the size of the eyes was not as pronounced; however, eyes of males were somewhat larger than eyes of females. On the basis of examination of numerous reared and wild-caught specimens of *C. angustifrons* from various localities in North America, Sabrosky (personal communication) has suggested two additional secondary sexual characters: (a) males have white hairs on the front femora, females black; and (b)

the hairs on the mesonotum are long in males, short in females. However, living flies were most easily sexed by noting the width of the epicranium, and the length of hairs on the mesonotum.

All efforts to induce mating failed, as no flies were observed to pair, and no fertile eggs were laid. Eggs laid were examined two days later by removal of the operculum. No larval development was evident. The eggs were held and examined once a week for three months, and then about once a month for a year. Larvae were never seen. It is important to retain eggs for observation over long periods since Parker and Wells (12) noted that eggs of *Cuterebra tenebrosa* contained active larvae which had not yet escaped from them, six months after deposit, and Gregson (6) reported that some larvae hatched normally from eggs of *Cuterebra tenebrosa* almost a year after being laid.

Flies (27 specimens of both sexes) lived from three and one-half to eleven days (average seven days). Fifteen males lived from three and one-half to ten days (average six and one-half days); twelve females lived from five to eleven days (average seven days). The length of life as here observed, and the fact that flies did not feed in the laboratory suggests a short life in nature.

Oviposition: Table 5 provides data on oviposition by flies which were observed to lay eggs. Eggs were deposited by unmated females two, four, five, six or seven days after emergence. In most cases, the eggs were laid within one or two days prior to death of female. Single females laid 111 to 2,511 eggs. The smaller numbers of eggs laid probably signify that the females had laid only a portion of the eggs produced by them, but this was not checked by dissection.

TABLE 5. LENGTH OF LIFE OF FEMALES AND NUMBER OF EGGS LAID

FEMALE NUMBER	DATE EMERGED (1956)	LENGTH OF LIFE IN DAYS	DATE OF EGG-LAYING (1956)	NUMBER OF EGGS LAID	REMARKS
61	May 3	6-½	May 5	111	Isolated until it laid eggs
26	May 7	6	May 12	364	
64	May 16	6	May 20-21	1596	Confined with No. 41 at time eggs were noted, thus eggs may have been laid by both flies
41	May 16	5	May 20-21		
25	May 20	7	May 24-25	2511	
47	July 11	11	July 19	710	
52	July 12	7	July 19	712	

The manner in which the eggs were laid is similar to that described for *Cuterebra lepivora* (14). The female extended its ovipositor and deposited eggs as it walked about on a strip of blotting paper. The ventral surface of the egg was cemented firmly to the substrate. Occasionally eggs were laid in clumps but generally eggs were deposited singly in long rows. Blotting paper was preferred to glass surfaces.

The eggs of *Cuterebra angustifrons* are similar to those of *C. lepivora* described by Ryckman and Lindt (14) and *C. emasculator* described by Bennett (2). The chorion is sculptured in a hexagonal pattern. An ovoid operculum is located on the dorsal surface at the anterior end. Measurements of forty specimens are as follows (in mm.): (a) Egg–0.96 (0.91 to 1.0) x 0.19 (0.17 to 0.2) (at base of operculum); (b) Operculum–0.26 (0.23 to 0.29) x 0.15 (0.14 to 0.17) (at greatest width).

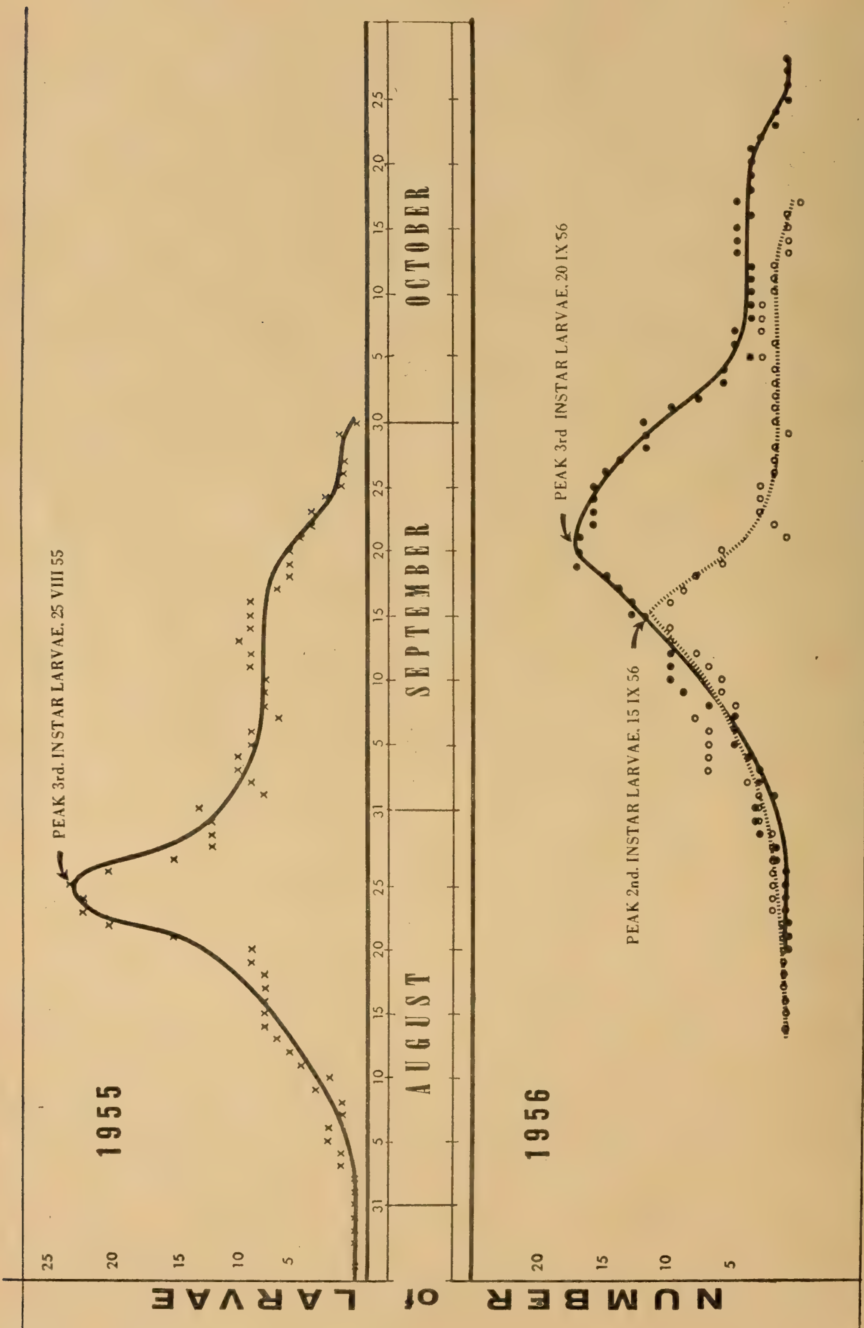

Figure 1. Seasonal incidence of third instar larvae for 1955, and second and third instar larvae for 1956. Second instar larvae, broken line. Third instar larvae, solid line.

SEASONAL INCIDENCE OF LARVAE IN THEIR HOSTS.

Fig. 1 presents graphically the incidence of second and third instar larvae as observed in mice trapped in the vicinity of Guelph and Brantford, Ontario, for the summers of 1955 and 1956. The data are summarized as follows:

	1955	1956
Second instar larvae first observed	July 13	August 14
Second instar larvae last observed	Sept. 30	Oct. 16
Third instar larvae first observed	July 19	August 25
Third instar larvae last observed	Sept. 30	Oct. 28
Peak of second instar larvae	Not observed	Sept. 15
Peak of third instar larvae	August 25	Sept. 20

The data demonstrate a shift in time of occurrence of second and third instar larvae as observed in their host in the summers of 1955 and 1956. The first observations of second and third instar larvae, and the peak of incidence of third instar larvae were delayed in 1956, 32, 24, and 26 days respectively behind 1955. Also the numbers of larvae seen in 1956 were about half those seen in 1955.

Some information is available on the chronology of stages of the life cycle of *C. angustifrons* and other cuterebrids. The earliest puparium in 1955 was formed August 8. The average length of the pupal period of pupae subjected to temperatures equivalent to those in nature was 315 days. Using this figure, a hypothetical adult might be expected to emerge June 18 of the following year. An adult *C. lepivora* was observed to mate 24 to 48 hours after emergence, and eggs were laid two to five days later (14). Eggs have been found "several days" after an adult *C. tenebrosa* was confined to a box in a laboratory (12) Penner and Pocius (13) recorded that larvae of *C. angustifrons* hatched from eggs in five to nine days. Larvae of *C. lepivora* began to hatch from eggs five days after being laid (14). Larvae began to hatch from eggs of a 'rabbit cuterebrid' four days after being laid (1). Using these data, our hypothetical adult mentioned above might have mated and commenced laying eggs by June 20. Larvae would begin to hatch about June 24, and some might have reached their host as early as June 25.

Parker and Wells (12) noted that "the total period from infestation to the emergence of fully developed larvae (*C. tenebrosa*) was respectively 37, 38 and 47 days in three instances." Penner and Pocius (13) observed (*C. angustifrons*) that "the average time in the host is 30 days although some grubs reach maturity and leave in 20." The average length of the third instar period of *C. angustifrons* as observed in this study was 11 days. The longest period of observation in this study of the second instar larva of *C. angustifrons* in the living host was six days. A figure of 31 days, then, might be quite reasonably assumed as an average length of the entire course of infestation in the host of *C. angustifrons*. This would mean in the case of our hypothetical chronology, the maturing of the larva on or about July 26. It is interesting to note that the first larva seen in 1955 did mature and leave its host July 26.

If we assume the foregoing to be a likely chronology of events of the life cycle of *C. angustifrons*, then an analysis of the mean soil temperature at four and twelve inches beneath exposed sod at the O.A.C. Soils Department Hydrologic Station (Guelph) for the period April 25 through the month of July in 1955 and 1956 would seem to be relevant. Ontario experienced in 1956 the most retarded spring since 1924. On April 24, 1955, the mean temperatures at four and twelve inches beneath the ground surface were respectively 44° F. and 51° F.; on the same date in 1956 the corresponding temperatures were 32° F. and 40° F.

From April 24 to the end of May, mean soil temperatures in 1956 averaged 4 to 10° F. lower at four inches, and 7° F. lower at 12 inches, than those in 1955. Not until June did the mean temperatures in the soil at the two levels in both years approximate each other, though for July and August of 1956, mean temperatures at both levels in the soil remained about 8° F. below the corresponding temperatures for 1955. Therefore it seems possible that depressed soil temperatures in 1956 as compared to 1955 might have been responsible for the appreciable delay in appearance of second and third instar larvae and peak incidence of third instar larvae in 1956 compared with 1955.

DISCUSSION

The evidence for a pupal diapause in the life history of *C. angustifrons* consists at the present time of these facts: the length of the pupal period regardless of the temperature conditions to which pupae were subjected, the emergence of an adult after a pupal period of only 42 days, and the restricted period of emergence of flies from puparia brought abruptly to room temperature from a period of cold. As diapause is essentially a timing mechanism (10) an important function here would seem to be assurance that numbers of both sexes of these short-lived flies should be present during the short period available for them for mating and oviposition. Another function would be provision for overwintering in the pupal stage. It is of interest here to note that Gregson (6) observed that eggs of *Cuterebra tenebrosa* contained active larvae which hatched normally almost a year after being laid; this suggests the possibility of diapause in the egg stage of this cuterebrid. Moilliet (11) observed the eggs of *C. tenebrosa* to withstand sub-freezing temperatures; thus there is the possibility of overwintering in the egg stage as well as the pupal stage.

Lower soil temperatures in 1956 compared to 1955 are thought to account for the shift in seasonal incidence of second and third instar larvae as observed in their hosts. Whether the effect was to prolong the supposed diapause in the pupal stage or prolong the post-diapause period is not known. The difference in numbers of larvae observed in 1956 compared to 1955 might be the result of removal of infested mice from woodlots in 1955 or of the climatic difference between 1956 and 1955 and its effect on emergence of adults.

SUMMARY

Thirty-one adult cuterebrids were successfully reared from 49 larvae which formed puparia. Thirty were determined as *Cuterebra angustifrons* Dalmat 1942, by comparison with Dalmat's type of that species. The remaining adult was identified as *Cuterebra grisea* Coquillet 1904.

Weights and dimensions of third instar larvae and puparia of *C. angustifrons* are recorded. There is a 15% weight loss during the first six days after formation of the puparium. The length of the third instar period averages 11 days, with a range of ten to 14 days.

Mean duration of pupal period in days (and range) and per cent of adults emerged from:

(1) Puparia at room temperature (18° C. to 24° C.) – 216.8 (192 to 237) –46% (6 of 13).

(2) Puparia at room temperature, 67 to 90 days; refrigerator at 7° C. for 148 days; room temperature, 30 to 48 days – 258.8 (245 to 274) – 72% (18 of 25).

(3) Puparia at temperatures approximating those at about two to four inches beneath the soil, during winter – 315.4 (301 to 333) – 70% (7 of 10).

Diapause in the pupal stage of *C. angustifrons* may be only inferred at present from the long pupal period here recorded, and the restricted period within which flies emerged from puparia shifted abruptly from a constant cold temperature to room temperature.

The pattern of emergence and behaviour of adult *C. angustifrons* is described.

Attempts to mate the flies were unsuccessful. Infertile eggs were deposited one at a time in a pattern of long rows corresponding to the path of the female on the substrate. The ventral surface of the egg was cemented firmly to the substrate. The eggs are elongate oval in shape, operculate, and have a heavy, sculptured chorion.

The appearance of second and third instar larvae, and the peak of incidence of third instar larvae were appreciably delayed in 1956 compared to 1955. Soil temperatures in 1956 are believed to account for the shift in seasonal incidence.

Some aspects of the identification and host relationships of *C. angustifrons* and other species of *Cuterebra* known to occur in Ontario are briefly discussed.

ACKNOWLEDGMENTS

I wish to thank D. I. Gillespie and T. H. Scholten for technical assistance in all phases of this work. Doctors G. F. Bennett, P. Morrison, A. J. Musgrave, and L. Wolfe have all contributed advice and criticism. Dr. W. E. Heming, in whose department this work was done, gave encouragement and material aid.

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A MUTANT OF THE INDIAN-MEAL MOTH, *PLODIA INTERPUNCTELLA* (HBN.) (LEPIDOPTERA: PHYCITIDAE) WITH A WHITE EYE[1]

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In June, 1955, a white-eyed mutant of *Plodia interpunctella* (Hbn.) was found in culture of moths that had been collected from a grain elevator in Midland, Ontario (Figs. 1 and 2). This mutation has not been reported before although eye colour mutations have been reported in a closely related species, *Ephestia kühniella* Zell. (2) and in many other insects (1, 3).

Pure cultures of the mutant moths were established by selection to determine the relationship between the white-eyed form and the normal, black-eyed form (Figs. 3 and 4). The white-eyed moths were mated with normal moths from laboratory stock cultures. The first-generation adults all had black eyes. The number of moths per culture averaged 137.6, ranging from 22 to 237. Then moths from one of these cultures were inbred. Approximately 25 per cent of

[1]Contribution No. 3539, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada; presented at the Annual Meeting of the Entomological Society of Ontario, Guelph, November 2, 1956.

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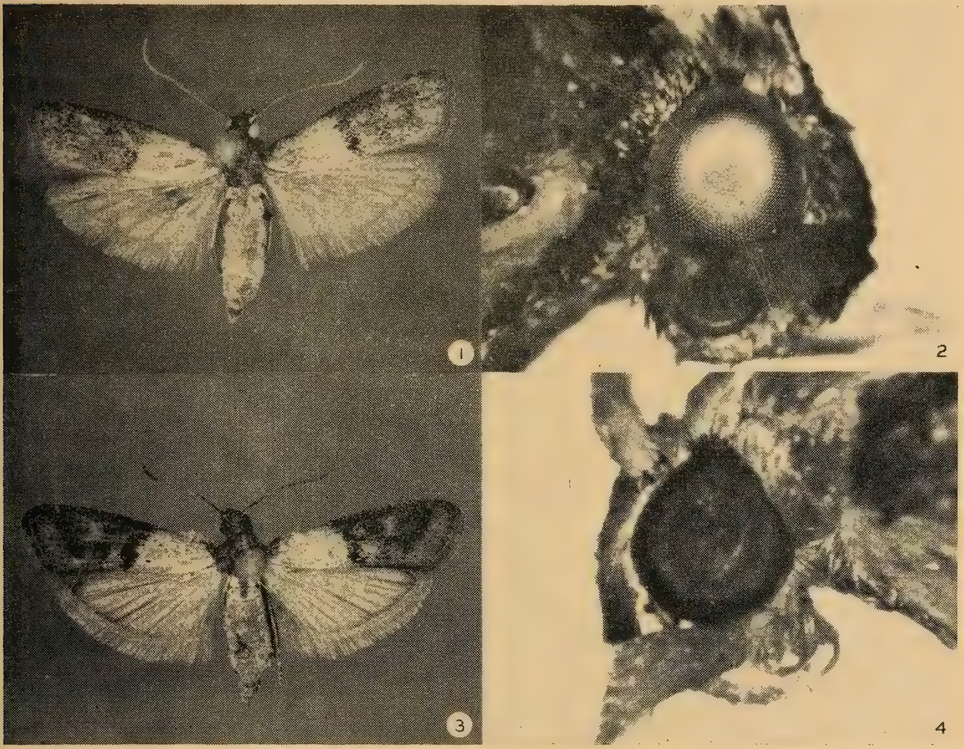
the progeny had white eyes and 75 per cent had black eyes. There was no gradation in the intensity of black colour. The average number of moths per culture of each eye colour was 27.4 white (range 5 to 50) and 88.6 black (range 41 to 153). A chi-square analysis showed that the results conformed to a 3:1 ratio. This indicates clearly that the white eye colour is recessive to the black. Backcrosses to the adults with white eyes further supported this conclusion.



Figs. 1-4. *Plodia interpunctella* (Hbn.). 1. A mutant with white eyes (approx. X10). 2. The white eye of a mutant (approx. X 60). 3. A normal moth (approx. X10). 4. The eye of a normal moth (approx. X60).

The eye colour of the mutant was not always expressed as white, for a number of adults with pink eyes were observed during the genetic studies. Attempts to select a pure pink-eyed strain of moth were unsuccessful. In the subsequent search for the cause of the pink colour, it was found that moths that developed from pupae kept in complete darkness all had pink eyes. Some exploratory experiments were performed on the effect of light on the eye colour of the mutant. The results obtained from them, while meagre, suggested that the amount of light falling on developing pupae affects the expression of eye colour in the mutant.

Some larval characters were apparently influenced by the mutation also. Those noted particularly were the pigmentation of testes, of the body (thorax and abdomen), and of the ocelli. Normal larvae have reddish to brownish-purple testes, a creamy yellow body with dorsal areas of pink, and light-coloured ocelli with a dark-brown central spot. Mutant larvae have colourless testes, a waxy white body, and ocelli that are completely light-coloured.

The development from egg to adult was approximately 30 days for both mutant and normal larvae.

The mutations in insect eye colour have been used to study colour inheritance by many workers (4). The work in this field on *E. kühniella* is especially significant in relation to the mutation in *P. interpunctella* since the close phylogenetic relationship between the two species strongly suggests that the development of colour is identical in each.

Futher work on the changes in behaviour associated with this mutation in eye colour of *P. interpunctella* would perhaps explain why the white-eyed moths are not seen more frequently in nature. There must be some factor in the environment that selectively eliminates them from wild populations.

ACKNOWLEDGMENTS

The author is deeply grateful for the assistance given by Dr. A. Wilkes during the study and in the preparation of the manuscript and for technical assistance from Mrs. M. L. Muir and Mrs. B. M. King, all of the Entomology Division, Ottawa.

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TRAINING THE ENTOMOLOGIST[1]

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Courses do not an insect-man make,
Nor degrees an entomological sage.

The very selection of the topic Training the Entomologist for discussion at these meetings implies some dissatisfaction with past and present training methods. I am not certain whether my selection as a speaker to this topic is a matter of the past catching up with me or the future coming back to meet me. I happened to be programme chairman for the 79th Annual Meeting of the Entomological Society of Ontario in 1948. For that meeting we arranged what proved to be a lively symposium on entomological training. With reference to the future I have been asked to organize a delegation to present views on teaching of entomology in Canada to the meetings of the Entomological Society of America, to be held in New York next December. (1956, Editor).

[1]Presented at the Annual Meeting of the Society in Guelph, Nov. 2nd, 1956.

Possibly the sub-title of my talk today requires some explanation. It is perhaps a feeble paraphrasing of two lines from Richard Lovelace's poem To Althea from Prison—"Stone walls do not a prison make, nor iron bars a cage". I am by no means implying that courses and degrees do not have a lot to do with making of the entomologist. The reply of a prisoner who had been interviewed by a lady visitor and was reminded that "Stone walls do not a prison make — — —" is pertinent to the present discussion: "No lady, but they sure do help a lot". And indeed courses and degrees help a lot in the making of the entomologist.

My theme today is, however, that there is "something else", something beyond courses and degrees, which is a very necessary component of the making of an entomologist. Before dealing with this in part intangible factor a few remarks to establish the background of the present discussion are advisable. The views to be presented are personal ones and only in part can I be certain of agreement from my colleagues. Nor do I wish these views to be taken as entirely fixed opinions not subject to change. No direct criticism of teachers of entomology or of particular institutions is intended. It is particularly important to keep in mind that these remarks are made by an "insect-man" who is most certainly not "an entomological sage".

There are many kinds of entomologists and I have in mind particularly the professional engaged in teaching or research. To a lesser extent my remarks will be applicable to the extension or commercial entomologist and to those engaged in administrative duties. It may be that the training of a student for extension work is more readily envisaged, but my own association with the field has been very limited.

With respect to training I am concerned with what happens through graduate training and beyond, for the majority of entomologists today who go into research or teaching proceed to a master's or doctor of philosophy degree. For the present I am not concerned with discussing specific courses. Although there seems to be general agreement on the necessity of a broad biological background there is probably a lack of such agreement as to specific courses. Most of us have changed our opinions from time to time and we would probably agree that complete uniformity would be undesirable. Specific course requirements change with the passage of time. We have only to witness the development of the biochemical field during the past two decades. Few entomology majors graduating before 1935 would have taken a course in biochemistry; today such a course is a part of the curriculum at most schools where entomologists are trained.

Although of necessity we are dealing with the training of the entomologist in the abstract, actual training involves individuals and the recognition of individual differences is of paramount importance. The larger the school in general the less the consideration that can be given to individuals who will differ as regards ability, industry, ambition and criteria of success at all stages of their professional careers. It is highly undesirable that we should attempt to pour all entomologists into one mold; we should, however, aim to provide the best opportunity for each individual.

In re-reading the report of the symposium at the 79th Annual Meeting of this Society in 1948 I found a few points which bear repeating.

1. The training of the entomologist should provide a general knowledge of the whole field of biology *and* a knowledge of processes of thought and experimentation by means of which scientific knowledge is advanced. Extensive reading and liberal experience with problems are aids toward achieving the latter.

2. Actual subjects are less important than *the way in which they are taught.*

3. The entomologist should not specialize too early.

4. Team research does not do away with the need for basic training for each member of a team. Only through this basic training can members of a research team appreciate one another's viewpoints and limitations.

5. Training should not stop with graduation at whatever level but should continue throughout the entomologist's professional career.

6. The employer is hiring "raw material" and any tendency to ear-mark new appointees particularly at the B.Sc. or M.Sc. level should be avoided.

The Something Else

The something extra, beyond courses and degrees as now given, can be dealt with from the standpoint of the University, the individual and the employer.

The University

The University's contribution apart from formal courses can be in a very concrete way and secondly in a more abstract way. With respect to the former we must teach our students to READ, WRITE, SPEAK and THINK and to work in harmony with their professional associates. Reading should be broad; the world of scientific literature (in its broadest sense) should be opened to the student. Ability to write can only be developed with practice and the value of that ability needs no supporting argument. Too few entomologists have learned the art of speaking; with respect to this point I would particularly call attention to a very common fault, that of the speaker neglecting to consider the particular audience for which he prepares a talk.

It is nothing new to suggest that students must learn to think. The problem is how to do this. Thought processes can be stimulated by reading, writing, and speaking and most particularly by requiring the student to deal with many problems — big and little and covering a broad field. The above-mentioned factors—Reading, Writing, Speaking, Thinking, should be the common denominators in the training of all entomologists regardless of the array of professional courses to which an individual is exposed. In my opinion if we can teach our students to think the field involved is of secondary importance. The student so trained, who has learned to cope with problems will be, within obvious limits, capable of expanding his activities to fields for which he has not had formal background.

In passing I want to mention the importance of the student entomologist learning to work in harmony with his colleagues. Stated in another way we must avoid turning out prima donnas. Someone has suggested that we may expect great scientists to be prima donnas. If this premise is acceptable we must be sure that our students see the path to "greatness". Prima donna is seldom a complimentary term when applied to the neophyte.

The more abstract contribution of the University to the training of the entomologist, and a contribution to which the employer can add significantly, can be summed up as guidance, encouragement and inspiration, all of which can only be effective through the teacher giving freely of his time apart from formal courses. To meet this challenge our teachers of entomology would needs be a race of supermen.

In a recent issue of the Entomology Division Newsletter Dr. R. E. Balch quoted the following: "Wise men learn from the experience of others — fools from their own experience". Balch went on to suggest that entomologists who

adjudge themselves in the latter group may blame their professors who exposed them to accumulated knowledge but have not told how this knowledge was obtained. This "how" can be imparted perhaps more through informal meetings of student and professor than by formal lectures. Here is where the student's interest and perhaps thought processes can be stimulated.

As an example, most students in medical entomology probably learn that Theobald Smith provided the first conclusive demonstration of arthropod transmission of a disease-causing agent (admitting that some authorities give the credit to Manson). It is probable that few students are familiar with the way in which Smith secured his evidence. This story does not necessarily make good lecture or seminar material but it is an excellent coffee-hour topic and can lead to all sorts of ramifications.

Much of what the teacher can give the student through informal contacts is more intangible than the foregoing example and can be expressed only as guidance, encouragement and inspiration. The result of this inspiration will be the awakening of the student's interest particularly with respect to reading more widely and a stirring of the thought processes with respect to a wide variety of problems. At this point it may be well to re-emphasize the factor of individual differences—and not only among students but as well among teachers.

This proposal that there should be more time spent in student-teacher association on an informal basis, is not intended to imply a leading, pushing or pulling of the student who must quickly learn to stand on his own, with a counselor ever available. These suggestions are of course particularly applicable to the training of graduate students. How does the professor find the necessary time? The number of students should be limited and in my opinion few instructors can capably direct more than four or five graduate students at the most. The relative merits of large and small schools or entomology departments are debatable. Certainly the advantage is with the small department where numbers of students are fewer and where by virtue of smallness the few staff members of necessity may have wider fields of interest. Obviously this view is coloured by my own position.

In recent years the supposed importance of a Ph.D. has been greatly magnified. Certainly some individuals have struggled through to that degree when they would have been better advised to have stopped at the M.A. level. If the professor has more time to give to his students he is in a better position to counsel them and the requirement of the M.A. as a possible stopping point might well be more widely adopted.

The Individual

Students should be aware that a significant aspect of the training of the entomologist lies with the individual. By and large the selection of a school for undergraduate work is probably largely a matter of circumstances. The individual is, however, in a position to use some judgment in selecting a school for advanced training. Over the years changes in economic conditions, employer regulations regarding educational leave, post-war D.V.A. credits and other conditions may influence an entomologist's decision to return to or continue his formal schooling and may in some respects determine the choice of institutions. In general it is inadvisable for the individual to do all his formal work at one institution. Perhaps the M.A. degree should be more widely used as a trial stage. The student who wishes to do graduate work but does not yet know what field of specialization to select might well continue at the school where he did his undergraduate work; and the student who has definite opinions should be advised to go elsewhere.

The relative merits of large and small departments should be discussed among students and the advice of people who have "been through the mill" should be sought. Students should take more initiative in looking into the type of training they will receive at a particular institution.

The student contemplating graduate work should be certain of a sincere interest rather than being influenced by what may appear to be restrictive promotional regulations. Currently it frequently happens that an entomologist works for several years before securing educational leave to continue his formal training. He may be faced with the choice of dropping his current programme or taking part of it with him as a thesis project. Here, individuality is again important and admittedly financial considerations may be paramount in influencing decisions.

Most of all the individual should appreciate that his training has not stopped with the completion of formal degree work. Self-initiated training may continue throughout the entomologist's career and I am certain that our leading entomologists have been students until their careers were ended. Again, depending on the individual and the training secured at university, guidance, encouragement and inspiration will be required of the employer in varying degree.

The Employer

The employer, at the laboratory head or unit-chief level has a major responsibility in the training of entomologists. Molding of the "raw material" is a task the significance of which does not appear to be universally recognized. Much of what has been said about the teacher can apply to the employer. A few concrete suggestions are the result of the speaker's accumulated experiences in contacts with employees and employers. Individuals should not be ear-marked at too early a stage in their professional careers. Recognition of individual differences is of major importance. There should be more active training sponsored through seminars and discussion groups particularly with the consideration of thought provoking topics covering a broad field. Particularly lamentable is the sometimes practised habit of hiring a Ph.D. who continues his thesis project which is at a later date fitted into a laboratory programme. This practise can be avoided by more active programming by leaders (self-training!) with the co-operation of younger entomologists who have been trained to view broad fields, to think and to express themselves.

The employer has a particular responsibility for those entomologists who want or should have educational leave. Guidance and encouragement with respect to the decisions which must be largely the individual's (see above) take time. This time must be found in order that snap-judgments and decisions based on one-man opinions do not play a major role in the training of the entomologist.

What Can Be Done?

It is easy to offer criticism even when that criticism is intended to be constructive. Consideration of all points brought out in the foregoing review is not possible within the time available. A few broad concepts may, however, form a point of departure for more detailed considerations at some future date.

1. Closer cooperation of university and employer is required. This cooperation is needed not for the purpose of setting up thesis projects but for a greater degree of mutual constructive criticism which in my opinion should be productive for the training of future entomologists.

2. The encouragement of good prospective students, encouragement at least to consider the choice of entomology as a professional field is an aspect of the training of entomologists in which all entomologists can take part.

3. At all levels we need time to *think*.

4. Finally, we, the teacher and the employer, need to be humble, humble in the face of the responsibility we assume for the training of the entomologist as a scientist, as an artist—for the practice of entomology is an art—and perhaps most of all, and to an extent more than we realize, as a fellow citizen.

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II. SYMPOSIUM

SOME HIGHLIGHTS AT THE XTH INTERNATIONAL CONGRESS OF ENTOMOLOGY

SOME HIGHLIGHTS OF THE CONGRESS

A Symposium of Essays

INTRODUCTION

As a part of the programme of the 93rd Annual Meeting of the Society, held at Guelph, in November 1956, certain members were invited by the Programme Committee to talk on "Highlights of the Congress".

We invited each of these speakers to submit his talk in the form of an essay for publication in this number of the Annual Report and suggested that each discuss and speculate upon the scientific parts of the Xth International Congress of Entomology that he found most interesting.

The Society is indebted to the essayists for providing the stimulating reading presented here.

However, it should be noted that not only does each essay represent, by request, the personal views of its author, but that many of the papers given at the Congress are not even mentioned by our essayists. Thus, it is evident that many of our members, after reading the essays, will decide that they would have selected papers or sessions as "Highlights" different from those presented by our essayists. This situation is inevitable when personal opinion is the criterion of selection: indeed, often, greater discussion is engendered thereby.

The Editor.

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ECOLOGY

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The field of ecology is, of course, very broad and its extent usually depends on an individual's interpretation of the subject. It is not surprising, then, that the general subject becomes gradually subdivided into a number of restricted categories. This was apparent at the Tenth International Congress of Entomology, where the control of insect pests by parasites, predators, and disease was considered in a section separate from ecology for the first time in the series of Congresses and where many papers presented in other sections might have been listed, equally justifiably, under ecology. Under these circumstances the section consisted of a somewhat limited number of sessions devoted to diversified papers and to one symposium on population theory. It was intended to hold a second symposium, on the contrasting approaches of laboratory and field population investigations, but this did not materialize.

Thirty-five papers were presented in the Ecology Section of the Congress; six of these dealt with laboratory populations and the remainder with field studies. The field studies can be divided rougly into the following groups: sampling techniques, one; bionomics of single species, 10; studies on two or more species in a community, 13; population theory, four; and general, one.

Taken together, the papers of the Ecology Section presented a great mass of detailed information on a diversity of subjects. Some papers, however, dealt with problems that were of interest to most ecologists and I will review these briefly.

It is desirable to study changes occurring in natural populations, but this is usually very difficult. Dr. N. Waloff presented a paper entitled "Methods of Interpreting Trends in Field Populations", in which certain indexes were used as measures of age and fecundity. The ages of populations of two species of moths were determined by the state of the internal reproductive organs and changes in weight from time of emergence. The fecundity of some grasshoppers was related to their mean weight by the use of laboratory data on the regression of the number of egg pods with the mean mature weight and the mean temperature of the oviposition period. Similarly, the fecundity of a chrysomelid beetle was related to the weekly mean temperature and the age of the population.

The interactions of two or more species formed the basis for several presentations and these gave some indication of the complexity of natural communities. In the paper "The Exploitation of *Pleurococcus* and Lichen by Insects", Dr. Edward Broadhead reported on eight species of psocids infesting the micro-flora on the bark of trees. Feeding preferences accounted to a large extent for the distributions of the species. Six species ate *Pleurococcus* and the remaining two were restricted to the lichen-covered dead branches of larch. One of these lichenophilous species attacked the whole of the lichen whereas the second fed only on the fructifying cups. At times densities of the psocids became high and it is likely that intra- and inter-species competition became intense. Dr. M. V. Brian, in the paper "Interaction between Ant Populations", dealt with the relations of species with respect to dominance and adaptation. For example, in fine mosaic habitats *Formica lemani* Bondroit takes the warmest. *Myrmica scabrinoides* Nylander the next, and *M. rubra* L. the least warm sites. This situation arises as a result of both inter-species adaptive differences and a dominance hierarchy; it is not a matter of preference, for when space is abundant all choose the warmest area. By means of special adaptations to suboptimal conditions the subordinate species are able to survive in progressively less favourable environments, depending on their positions in the power heirarchy. Dr. C. A. Fleschner discussed the balance of plant-feeding mites on citrus in "The Field Approach to Population Problems". Removing predacious mites from the natural community showed that these predators were responsible for maintaining the plant-feeding mites at a low density. Many factors of the environment influenced the effectiveness of the natural enemies. J. Linsley Gressitt described the biological control of the coconut beetle, *Promecotheca papuana* Csiki in New Britain. It was controlled by the imported parasite *Pleurotropis parvulus* Ferr. except when a build-up of populations of the mite *Pyemotes ventricosus* (Newp.) produced an abnormal one-stage condition of the host insect. The increase of the mite is probably associated with abnormally dry seasons.

One of the high points of the Congress was the symposium on population theory. There are two opposing views on the regulation of the numbers of insects in nature. One stresses the importance of the population, through its effect on its governing requisites, in the regulation of its own numbers, whereas the other emphasizes the intrinsic limitations of organisms and the discontinuity and variability of the physical environment. It was to be expected then that the symposium would center on these opposing concepts.

Dr. C. B. Huffaker's view was that population dynamics rest on three concepts: (1) the properties of the biotic elements; (2) the furnishing of the requisites by the environment; and (3) the competitive untilization of those

requisites. If the physical requisites are relatively constant, competition for them dominates and exerts the conspicuous control. On the other hand, fortuitous changes in the levels of the requisites (e.g., by weather) may dominate the scene and repeatedly short-circuit or obscure the tendency for competition to establish balance for any prevailing conditions.

Further support for the population concept of Dr. A. J. Nicholson came from Dr. G. C. Varley. A census of lepidopterous larvae feeding on oak indicated that all the species fluctuated to a similar extent but that some were common and others rare. The fluctuations were attributed in part to weather factors and in part to specific parasites. The commonness and rareness of hosts were considered to arise from the action of specific parasites with differing areas of discovery or mortality. The fact that the population cycles were damped, instead of following the mathematical theory, was discussed. In the Forest Entomology Section, A. D. Voûte attributed this damping effect to the action of birds, ants, food-shortage, crowding, emigration or immigration.

A combination of both views was proposed by Dr. Alec Milne, who put forward the following theory: "A perfectly density dependent factor or process will control numbers endlessly. There is only one such in Nature for any species and that is the competition between its own individuals. This is the ultimate controlling factor. But in Nature, most species, in most places for most of the time, are held fluctuating at population levels where this factor is seldom evoked. The suggestion therefore must be that control is, for most of the time if not almost endlessly a matter of the *combined* action of factors which are density independent and factors which are imperfectly density dependent, *each supplying the lack of the other*".

The effect of random fluctuations of a great many environmental factors was considered by Dr. L. C. Cole to be of prime importance in determining the lengths of population cycles. There was a close correspondence between the number of cycles of a given length – mostly in vertebrates – and a theoretical distribution of cycle length derived on the assumption that the increase or decrease in the size of the population is entirely a matter of chance resulting from random fluctuations in the favourability of the environment. Consequently this hypothesis of randomness is the one to accept until data become available that require a more complex explanation. This approach of randomness was also proposed in the Forest Entomology Section by Dr. F. Schwerdtfeger, who used a model of black and white marbles. A white marble meant one unit of population increase while a black marble meant one unit of decrease. Large numbers of marbles being drawn from a bag, the numbers of white and black marbles determined the amount of population change during each generation. The theoretical growth-form derived by the chance play of favourable and unfavourable environmental factors corresponded with those recorded in German forests.

At the end of the symposium there was a spirited discussion of the papers. One point acceptable to all was made by Dr. W. R. Thompson, who suggested that all jargon be dropped and the subject discussed in simple English.

Most sessions of the Ecology Section contained a heterogeneous group of subjects and on many occasions the audience was rather small. Contrary to expectation, however, these conditions led to many detailed discussions of the presentations and so the ecological significance of the topics was emphasized.

One of the benefits of the papers given on insect ecology is the fact that they permit a stock-taking of this field and allow speculation on its future course. Those sections of the Congress that dealt with the control of insect pests con-

tained many papers of an ecological nature; for example, the use of life tables for the estimation of the relative mortalities attributable to several environmental factors or the changes recorded in the relative abundance of insect pests after the application of insecticides. The restricted field of ecology, on the other hand, was concerned with the problems of the regulation of insect numbers in nature —not necessarily at an economic level—and with the structure of insect communities. The papers of this section dealt with long-term research programs rather than with immediate economic problems.

Judging from the program of the Ecology Section, there appear to be three trends in ecological research. Studies on field populations are becoming more quantitative through the use of more refined sampling techniques and observation of more environmental variables. Experimental populations are being used to study how certain mechanisms operate rather than as alternatives to natural populations. Finally, there is increased work on the theoretical approach to the regulation of insect numbers necessary in defining problems that need empirical investigation.

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BIOLOGICAL CONTROL

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During the Tenth International Congress of Entomology 89 papers dealing principally with biological control in at least one of its many aspects were read. Twenty-three of these were presented by Canadian authors. The papers may be loosely classified as follows: 21 on ecological studies, life-histories, behaviour, or morphology of parasites and predators in the field or the laboratory; 12 on control by pathogenic organisms; five on biological control of weeds; one on serological methods of use in studies of control by disease; eight on surveys of progress in biological control in various countries; five on surveys of attempts at biological control of specific pests; one on a survey of biological control in time; two on plant resistance as an agent of biological control; eight on laboratory experiments in parasite-host or predator-prey relationships; seven on theories of biological control, either in general or concerning specific problems; nine on the effects of cultural practices on specific parasites or predators, or the efficiency of biological control of particular pest species; ten on the value of biological control for particular pest species, three being preliminary reports and seven being on completed experiments or investigations of which four were judged to be successful.

This is a review of the program as a whole, with more detailed discussion of the symposium on orchard mites and their natural enemies, a session of particular interest to the writer.

The most striking general impression of the meetings was the high regard in which biological control is held in North America, particularly in Canada. That this fact is even worth mentioning may surprise many readers but I am used to a very different situation. In England, where I spent the last three and a half years, meetings at which papers on biological control are presented frequently become general discussions of whether any effort expended on the study

of this matter is not a complete waste of time. This is usually initiated by one or two vehement people but the average British entomologist seems to give little thought to parasites and predators unless he is interested in natural history. Those working with these organisms and striving for a sane balance between the use of biological and chemical control in agriculture are frequently regarded as deranged but somewhat amusing. This attitude is, of course, not universal in England, but it is much more noticeable than in Canada and constitutes a very disturbing influence.

This difference in thought between the two countries inevitably leads one to wonder whether perhaps many of our contemporaries on this continent are too enthusiastic about biological control, and some of the papers presented at the Congress provided confirmation of this. A number of papers, particularly those that surveyed the accomplishments achieved in various countries by the importation of natural enemies, consisted largely of long lists of insect pests that have been kept under control by this method. Entomologists studying predator-prey or parasite-host relationships under field conditions know how extremely difficult it is to prove the causal relationship in population fluctuations. Even with the improved methods, facilities, and staff available today it is frequently impossible to do so, and in many instances conclusions are merely deductive and relate to what has probably taken place if the reasoning of the investigator is not at fault. Too many of the Congress papers merely listed results as either successful or unsuccessful. No one is likely to argue with the latter conclusion, but the impression cannot be escaped that in the former a considerable degree of naivety is required before the results can be accepted completely.

This matter was admirably commented upon in a paper by Dr. H. L. Sweetman (U.S.A.). He listed the pest species proved to have been controlled by biological agents and, though the list is impressive, it falls far short of the number that entomologists have claimed were controlled in this way. Undoubtedly, many of these claims are indeed genuine, but any conclusions or discussions on the relative merit of biological control must rest upon acceptable scientific evidence, not merely upon speculation.

By no means all of the papers dealing with the control of specific pests were guilty of this fault. Papers such as that by Dr. G. N. Wolcott (Puerto Rico) leave little doubt that the situation as described really does prevail. Also, those papers that dealt with studies on the complexes of natural enemies that affect certain pests usually gave the impression that, though in many instances the problems were not yet solved, at least the situations were in hand and hasty or unsubstantiated conclusions were not likely to be advanced. The Canadians and others, such as Dr. J. Franz (Germany) and Dr. W. A. Baker (U.S.A.), were outstanding in this regard and one feels these workers are fully aware of the difficulties inherent in assessing natural control and that they meticulously attempt to consolidate each step in their research programs rather than bypass such time- and energy-consuming methods to leap to a hasty conclusion.

Some of the papers of greatest value to those interested in biological control were read in sessions of the Ecology Section. These dealt largely with population interaction and will undoubtedly be discussed under that section. However, the comment is not out of place here that many of these left the reader with a feeling of satisfaction; extreme viewpoints concerning the mechanisms and factors governing population balance were not greatly in evidence and there was a welcome attempt to incorporate the most acceptable features of various theories into conservative and moderate statements of situations.

Eleven papers were presented at the meeting on orchard mites and their natural enemies which lasted a whole day, and the program was well-rounded, stimulating, and informative. Speakers had been asked to emphasize the interaction of orchard mites and their natural enemies, and to express their convictions regarding the role, both actual and potential, of biological control in orchard economy as related to phytophagous mites. Without exception the speakers were optimistic about the beneficial results to be obtained from natural enemies in orchards, though some were more conservative than others, depending on the outlook for success in the areas in which they work. However, when convictions on the value of specific predators and groups of predators were expressed, it was obvious that in many instances there is a decided lack of unanimity. This was particularly true of predacious mites of the family Phytoseiidae.

The papers might be placed in two categories, although some had elements of both. These groups were: those with a chemical approach to the problem of determining the role of natural enemies in the control of phytophagous mites and those with an ecological approach. Among the former, which dealt mostly with predator complexes rather than individual species, were papers by Dr. D. W. Clancy (U.S.A.), Dr. G. Mathys (Switzerland), Mr. van de Vrie and Dr. H. J. de Fluiter (Holland), and Mr. F. T. Lord and his associates (Canada). These demonstrated conclusively (as these and other workers have shown many times) that the introduction of certain toxic sprays into the orchard environment is almost certain to intensify damage by phytophagous tetranychid and eriophyid mites. It was strongly suggested that such a result was caused by virtual elimination of natural enemies, most of which are more affected by such sprays than are the pests and rebuild populations more slowly after the applications. There is little doubt that this interpretation is correct, but Dr. D. J. Kuenen (Holland) pointed out that one must not neglect the possibility that such sprays also favour increase in reproduction of the pest species or in some other way alter the environment in their favour.

There are two methods of utilizing this information in devising spray programs that will enable natural enemies to contribute to the control of pest species. The first, used by Mathys, is to test a wide variety of chemicals under laboratory conditions to determine their effects on predators. With this information an intelligent choice of compounds can be made to formulate the program. The difficulty here lies, of course, in the artificiality of such laboratory procedures and in the multitude of factors, such as time of application, climatic conditions, and the condition of the host plant, that may influence the effect of a spray.

The other method is to test a wide variety of chemicals in the field, both singly and in combination, and with this basis to formulate a program that will be harmless to natural enemies and yet fulfil its function. This method has the disadvantages of requiring a huge expanse of orchard in which to work and of being exceedingly time-consuming. It has, nevertheless, proved of great value in Eastern Canada, where Mr. A. D. Pickett and his staff have devised a modified program that allows a high degree of biological control in their orchards.

Up to this point I am in full agreement with the methods and the evaluation of the results. However, the chemical approach, which is very suitable for studies designed to increase the populations of all groups of predators in orchards, has been extended for use as a tool in deciding which of the groups is most beneficial, and therefore most worth favouring. I consider that this method is not sufficiently precise for detailed and exacting work of this nature. It is sufficiently difficult to attempt to understand population interactions under field conditions without introducing a chemical into the environment whose

subtle influences probably completely escape our notice. It is true that valuable clues as to which group of natural enemies plays the most important role in regulating population density of the pest may be obtained in this way. However, proof cannot be obtained and it would be inadvisable to trust in the results too implicitly.

Proof of such matters can only be obtained by detailed ecological studies, and several papers were devoted in part or entirely to these. Unfortunately, it was these that lead to the greatest controversies on the importance of predacious mites, but these can be resolved as explained below. Miss E. Collyer and Dr. A. M. Massee (England) demonstrated the value of certain Hemiptera and other predacious insects in English orchards, and others, such as W. L. Putman and D. C. Herne (Canada), De Fluiter, Mathys, and Lord and his associates, confirm that this is the case in other areas as well. However, N. H. Anderson and C. V. G. Morgan (Canada) consider that in British Columbia the complex of predacious insects is too small and the number of individuals so low that little can be expected of them in the control of phytophagous mites. The predacious mites found in British Columbia orchards apparently feed but little on tetranychids and therefore are of little value. D. W. Clancy showed that in West Virginia the numbers of predacious insects are also small, although predacious mites may be of importance. D. A. Chant (Canada), reporting on a study conducted in England, showed that the species of predacious mite abundant in English orchards is probably not an effective predator of tetranychid mites. The predator feeds to some extent on these pests but its effect is dissipated by its habit of feeding also on plant juices and on fungal spores and plant pollen. Also, an analysis of the distributions of both predator and prey within apple trees showed that the two populations do not have the same preferences, and therefore do not inhabit the same areas. The result is that at all times a portion of the prey population is free from the predator.

There were, therefore, two papers that claimed that predacious mites are of little or no value in controlling phytophagous mites. There were four others that took the opposite view, and Dr. D. W. Clancy and Dr. M. H. Muma (U.S.A.) showed that they consider these predators to be important under certain circumstances where conditions are favourable and where other mortality factors are also acting on the pest population. Muma's paper was unique in that it also discussed the role of disease organisms in the control of phytophagous orchard mites. This is a subject about which we were almost totally ignorant and had it not been for Muma and his co-workers we still would not realize the extent to which this mortality factor can influence population densities under certain conditions. Various entomologists have speculated for some years that disease organisms are one of the major factors responsible for the low tetranychid and eriophyid populations that usually occur in derelict orchards. Under commercial conditions these organisms are eliminated by routine applications of fungicides, and the pest populations increase greatly. Muma's work helps to remove this belief from the realm of speculation and it now seems probable that disease is at least one of the factors acting in this way.

Taking an extremely favourable view of the role of predacious mites in this controversy were Dr. C. A. Fleschner (U.S.A.), Mathys, and Lord and his associates. Mathys and Lord both have evidence to support this view but both agree that it is not entirely conclusive. On the other hand, Fleschner demonstrated beyond doubt that the predacious mites in citrus and avocado groves in California are at times an extremely important factor in regulating phytophagous mite populations. Many ingenious experiments were used to develop and substantiate this view, one being based on the removal of predacious mites by

hand-picking to establish gradients. This method has been used before, of couse, but never before with such small organisms as mites in an environment such as an apple tree. Chant used a somewhat similar method in his work in England but it was neither as laborious nor as precise. Obviously, more of this type of work is needed if sound estimates of the value of various predators are to be obtained; predator gradients must be established to study the resulting effects on the pests, and the use of physical means for this purpose introduces fewer influences of whose effect we are ignorant than does the use of selective insecticides and acaricides.

The conclusion most evident as a result of this controversy concerning the value of various predacious species was almost ridiculous in its simplicity but had not previously been agreed upon by such a large gathering of entomologists and acarologists: each species must be treated as an individual and what prevails in one fruit-growing area need not necessarily prevail in another. In the past there has been a tendency to consider predacious mirids, or coccinellids, or Phytoseiidae as either good or poor predators; the untenability of such all-inclusive views was made obvious to all who attended this symposium.

Impromptu discussion at this meeting was also of value, though largely in a rather negative fashion. These discussions were often centred on the question of how closely various predators approximate our concepts of ideal predation, and of the manner in which their various biotic characteristics either enhance or detract from their value as predacious organisms. At every step in such discussion one was blocked by what cannot be described as anything but sheer ignorance on the details of the life-histories, habits, and ecology of the insects and mites under discussion. Clearly, what is needed is not expanded investigations of the precise effects of further chemicals on these beneficial organisms but rather intensive investigations on their life-histories and ecology. When this information is available, truly intelligent efforts can be made to utilize predators for the solution of orchard problems.

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FRUIT INSECTS

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The modern, nearly world-wide, approach to the problems of orchard entomology was well illustrated at the Congress, where approximately 75 per cent of the 25 papers on fruit insects dealt with the effects of pesticides on the orchard fauna, or on the biology of natural enemies of fruit insects and mites. Only two papers, both on tropical fruit flies, dealt with the insecticidal control of individual pests.

This does not necessarily mean that the use of pesticides in orchards is generally decreasing; many entomologists undoubtedly considered that much empirical research on chemical control did not provide papers of sufficiently wide interest for presentation at the Congress. However, it does emphasize that all fruit entomologists are becoming increasingly aware of the short- and long-term bad effects that may accompany or follow present chemical control practices. Such effects, long known for some of the older pesticides, have been more

pronounced since the recent introduction of many more potent insecticides. Examples of the problems brought about are the upsurge of phytophagous mites that often follows the use of DDT, at least in part due to the destruction of natural enemies; and the comparatively rapid development of resistance to chemicals such as that to phosphate materials by the European red mite, to DDT by the codling moth, and to DDD by the red-banded leaf roller, to mention some North American examples.

Papers by Massee (England), Kuenan, Van de vrie, and de Fluiter (Holland), Pickett, Putman, and LeRoux, and Downing, Marshall, Pielou, and Proverbs (Canada), and Fleschner, Clancy and McAlister, Muma, De Bach, and Chapman (U.S.A.), all emphasized the importance that is now being placed on finding out as much as possible about all the effects of pesticide chemicals in orchards. These workers were in apparent agreement on the scientific importance of such ecological investigations but there were wide, and outspoken, differences in opinion on the commercial value of attempts to harmonize chemical and biological control under orchard conditions.

The work in England reported by Massee is more advanced than most on the biology of predacious forms in orchards, and he considered that this basic knowledge, coupled with the concurrent findings on the effects of chemicals on these forms, offers the best hope for reducing control costs in the future. He emphasized that his work as yet has produced few results of direct commercial value to the fruit industry. Pickett, on the other hand, presented the well-known advances, already in commercial use, made in Nova Scotia in the control of mites, the oystershell scale, and to a lesser extent the codling moth and the eye-spotted bud moth, by the so-called modified spray schedules that replace more toxic insecticides and fungicides with those that are relatively innocuous to important parasites and predators.

De Bach showed the very considerable improvements in control recommendations for citrus pests that have been made in California by the application of sound ecological information, including the selection and timing of insecticides that lessened the destruction of natural enemies.

Clancy reported on his successful work in Virginia where ryania, in combination with the fungicide captan or glyodin, all relatively innocuous to many predators, gave as good control of the codling moth and usually, although not as rapidly, of orchard mites as DDT combined with a miticide and a sulphur fungicide. However, because of the relatively high cost of ryania, and because it must be applied as often as DDT, its only present commercial advantages are against strains of the codling moth that are resistant to DDT, or where a DDT residue problem exists. Pickett, Putman, and LeRoux also reported on successful control of the codling moth with ryania in Canada. In the comparatively cool apple growing areas in Nova Scotia and Quebec, where the codling moth is largely one-brooded, 'modified' spray schedules including ryania have been economically successful; but in the parts of southern Ontario where the codling moth is two-brooded and consequently presents a much greater threat, the use of ryania merely substitutes a more expensive spray schedule for the cheaper and equally effective DDT schedule. Several years of study at Vineland Station, not reported at the Congress, indicate little likelihood that, even under the most favourable host-predator relationships, the amount of ryania could be safely reduced.

Putman, in a resumé of his extensive investigations on the effects of pesticides on the fauna of peach orchards in Ontario, demonstrated that DDT, and to a lesser extent sulphur, were largely responsible for the recent abundance of the

European red mite and the two-spotted spider mite. However, Boyce and Dustan, also in Ontario, showed that the extensive use of DDT and parathion for the control of the oriental fruit moth has not reduced the high degree of parasitism of this pest by the imported parasite *Macrocentrus ancylivorus* Rohw. Because chemical control of the fruit moth is still needed and no effective substitutes for DDT and parathion have been found, the attempts to harmonize chemical and biological control of all pests of peach in Ontario have, after 10 years, given no results of commercial value to the peach industry.

Chapman of New York and Marshall *et al.* of British Columbia, in able contributions to 'Contrasting Approaches to Orchard Entomology', implied that laboratories of applied entomology should carefully assess their pest conditions and the economy of their local fruit industries before embarking on extensive ecological investigations. Chapman claimed that despite the high cost of chemicals for pest control on apple in New York, comprising approximately 40 per cent of the total cost of fruit production, growers in his area are likely to rely primarily on pesticides because of their reliability and high efficiency. He pointed out that the best insect control obtained on apple anywhere to date or likely to be obtained in the foreseeable future by so-called modified spray schedules cannot be expected to give the high percentage of high-quality fruit that the growers need to survive in the present competitive market. He believes that in areas such as his, where the destructive potential of apple pests has been high for many years, the purely chemical approach to such problems as resistance and the upsurge of new or previously minor pests is more likely to give economically satisfactory results than the biological approach.

Marshall brought out clearly the importance of local pest conditions in determining the most profitable lines of research for fruit insect laboratories. He gave a graphic illustration of the benefits to be derived from what he called the 'flexible approach in orchard entomology' in British Columbia, where for many years the ill effects of pesticides have been feared and, where possible, avoided. During the past 10 years, research on apple pest control, primarily on the codling moth, has changed the control program from one of the most difficult and expensive on the continent to probably the most economical. This was done by revolutionary improvements in application equipment and by the finding that DDT in a few, well-timed applications gave outstanding control of the codling moth under the climatic conditions prevailing in the valleys of the interior of southern British Columbia. Annual control measures for orchard mites are needed, and resistance to phosphate acaricides is widespread, but further reductions in control costs are more likely to come from the more efficient use of acaricides than by selective insecticides. Ryania has not given satisfactory economical control of the codling moth in British Columbia and has injured some varieties of apple.

The purely biological aspects of parasites and predators and of their relationship to pesticide chemicals are reviewed in more detail by Dr. D. A. Chant elsewhere in this symposium.

Divergent views were expressed by different workers on the future trends in orchard pest control. Some strongly believe that natural enemies of orchard pests will have to be utilized extensively, in combination with highly selective pesticides for incipient outbreaks. Others believe that, because the development of a wide range of selective materials is an exceedingly difficult undertaking and because there is no assurance that these themselves will not produce resistance problems, the fruit industry is more likely to be benefited by the development of new materials that are highly toxic to a wide range of pests, including those with strains resistant to older materials, and which only by chance may allow significant control by natural enemies.

In conclusion, the evidence presented at the Congress left little doubt that control practices throughout the world for orchard pests will continue to vary widely, depending on the economics of the fruit industries, on the potential destructiveness of the pests, and on local efficiency of natural enemies.

TOXICOLOGY AND PHYSIOLOGY

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INSECT HORMONES:

The rapid advances which have now established that the regulation of insect metamorphosis and diapause is hormonal in character made the symposium on the nature, origin and activity of the insect hormones most opportune. Indeed, so recent have been these developments that it was possible to hear first-hand those pioneers who, by a skilful adaptation of the methods of vertebrate endocrinology and by novel methods which take advantage of the ability of the insect to survive drastic surgical intervention, have been responsible for these advances.

Dr. Berta Scharrer vividly described the histophysiological studies of her laboratory on the *corpus allatum* of the cockroach *Leucophaea maderae.* These studies have enabled the interpretation of the functions of this gland and of the feed-back mechanism involving neuro-secretory cells in the proto-cerebrum. Her contribution was complemented by Dr. B. Possempès' paper on the same gland in the stick insect *Sipyloidea sipylus.*

A specific example of the implantation technique was given by Dr. M. Ichikawa who described Japanese work on the pupae of *Philosamia cynthia ricine* (Lepidoptera). Neuro-secretory cells from the brains of pupae were implanted into other brainless pupae and all recipients in which the grafts were viable developed into moths. More general accounts were given by three masters of the subject, Dr. V. B. Wigglesworth of Cambridge, Dr. Carroll M. Williams of Harvard, and Dr. A. F. O'Farrell of the University of Sydney. The latter author described regeneration and moulting in cockroaches; Dr. Wigglesworth dealt with those aspects of his work which concern the hormonal control of metamorphosis and growth in *Rhodnius.* Dr. Carroll Williams not only described his recent work on the juvenile hormone, a subject which will be discussed further below, but gave a superbly illustrated talk on the ingenious manipulations of the *Cecropia,* silkworm by which he and his colleagues have exposed the hormonal mechanisms controlling metamorphosis in this insect. This latter talk given at 24-hours notice filled the gap created by the unfortunate absence of Dr. D. Bodenstein who was to speak on the hormonal aspects of insect regeneration.

The biochemical task of determining the nature and properties of the hormones themselves is simplified by the evidence that these chemicals are not species-specific. For example, the "juvenile hormone" of the Cecropia silkworm retains its action, as Dr. Williams reported, in *Pieris brassicae, Tenebrio molitor, Rhodnius prolixus* and *Periplaneta americana,* in that the formation of the adult insect is blocked. Similarly the prothoracic gland hormone isolated from *Bombyx* pupae by Dr. P. Karlson was effective in terminating larval diapause in the sawfly *Cimbex americana* and induced a decapitated *Rhodnius* to molt.

The work of the Tubingen group on the isolation of the latter hormone was described by Dr. P. Karlson. Two years ago this group recovered this hormone, which they named "ecdysone," in crystalline form. Its probable formula is $C_{18}H_{30}O_4$ and spectrographic data indicated the presence in the molecule of an α, β-unsaturated keto group. Unfortunately, the yields obtained were but 25 mg. from 500 kg. of *Bombyx* pupae, so low that insufficient material was available for elucidation of the structural formula. However, 75 mg. was recovered from 17 kg. of *Calliphora* pupae and its identity with the hormone isolated from *Bombyx* was established by paper chromatography. The advances achieved by Dr. Karlson and his colleagues are remarkable in that the only bioassay technique available at that time for the measurement of the activity of their extracts required the tedious and skillful ligaturing of hundreds of *Calliphora* larvae. The need for this time-consuming process may be reduced now that the chromatographic and absorption properties of the active hormone are known.

The hormone of the *corpus allatum* which, because it opposes or prevents metamorphosis in immature insects is known as the juvenile hormone, was found by Williams to be present in extremely small amounts in the heads and thoraces of male *Cecropia* moths. Yet curiously and fortunately he found a rich depot of the hormone in the abdomen of these males. The hormone which was recovered is an oil of low viscosity but is heat stable.

The isolation of these two hormones will permit a more precise experimentation upon their functions, not only in insects from which they were isolated but, for instance, in the determination of caste in bee and termite colonies. The latter subjects were not included in the program of the Physiology and Toxicology section but have been reviewed by Dr. H. E. Hinton in the April, 1955 issue of "Science Progress."

Moreover, their isolation will now permit the biochemist and the organic chemist to attack the molecular structure of these hormones and the outcome of their work will be impatiently awaited. Dr. Carroll Williams was able to suggest that the juvenile hormone may have practical use for the control of noxious insects, for he found that the hormone is able to transverse the insect cuticle. Light petroleum extracts of the abdomen of male *Cecropia* moths when applied topically to pupae induced the development of a monstrosity, part pupa, part adult. Dr. Williams pointed out that if the hormone can be identified and synthesized, it may prove an effective insecticide to which the prospects of the development of resistance would be remote. It would appear from Dr. Williams' statement that the period over which the hormone is effective is restricted to the first few days of pupal development though this limitation may not restrict the period which the hormone could be effectively used as an insecticide.

INSECTICIDE RESISTANCE:

The symposium entitled, "Resistance to Insecticides" permitted the presentation of three important review papers. Dr. A. W. A. Brown surveyed the reported cases of the development, in insects, of a substantial degree of resistance to insecticides once effective in their control. Instances from among phytophagous insects are not too frequent, but resistance to chlorinated hydrocarbons is now present in at least 10 of the important vectors of human disease and in 27 other species of public health importance. This situation is so serious that the World Health Organization has set up an international body to collect accurate information, to survey by standard tests the extent of the resistance reported, and to assist in the coordination of the work of the various laboratories in which the problems of insecticide resistance are being studied.

Dr. A. S. Perry of the Savannah Laboratories of the U.S. Dept. of Health dealt specifically with the nature of DDT resistance in the housefly. He classified the possible protective mechanisms as behaviouristic, morphologic and physiologic. The behaviouristic hypotheses concern differences in resting habits, emergence characteristics, etc., whereas the morphologic factors associated with resistance include cuticle thickness, diameter of puvilli, and other structural differences. A variety of physiologic differences have been advanced as reasons for resistance, ranging from differences in enzyme activity, particularly of the cytochrome oxidase, to an ability to store DDT in non-sensitive tissues. In connection with the latter hypothesis it was mentioned in the discussion of Perry's paper that Wiesman had recently found that the injection of lipase rendered DDT-resistant flies susceptible.

Of the physiologic hypotheses, that which has the greatest experimental support is that resistance is the result of the presence in the cuticle of resistant insects of an enzyme which, being able to catalyse the dehydrochlorination of DDT to the non-insecticidal ethylene, has been named DDT-dehydrochlorinase. Perry concluded that the complex nature of DDT-resistance makes it difficult to characterise the phenomenon in terms of a single common factor. He suggested that each strain of resistant houseflies possesses a combination of attributes for resistance which is different from that found in other strains.

The study of the metabolic changes of DDT has been carried out in the University of California, and Dr. W. M. Hoskins gave a coordinated account of this work. At least three situations are found:—firstly, there may be no appreciable metabolism of DDT during a critical period and the DDT is recovered unchanged, as from several of the highly DDT-susceptible lepidopterous larvae. In the second category the main metabolic product is the ethylene, a feature especially of the highly DDT-resistant strains of houseflies. In the third category not only ethylene but one or more water-soluble products of DDT are to be recovered, as from the cockroach. The recognition of these water-soluble derivatives has been difficult but certain of them have been tentatively identified.

The symposium included two papers dealing specifically with the possible use of synergists to augment the activity of DDT and to render DDT-resistant strains more susceptible. Dr. F. O. Morrison referred to the work of his Department at Macdonald College on the use of compounds containing a bridged dichlorophenyl structure such as bis (*p*-chlorophenyl) methane and 1,1-bis (*p*-chlorophenyl) ethane. The basis of this work is the idea that if resistance is effected through a dehydrochlorinase, the enzyme may be inhibited, perhaps competitively, by a compound of structure akin to DDT.

Among compounds found in earlier work to enhance the activity of DDT in DDT-resistant houseflies were derivatives of benzenesulphonanilide. Unfortunately the effective compounds were too insoluble in hydrocarbons to be of practical use in DDT formulations. Dr. M. Neeman of the Technion Israel Institute of Technology submitted a paper in which he and his colleagues have sought to correct this defect. Benzenesulphonanilides substituted by halogen in the *para* position and with *N*-alkyl radicals from C_1 to C_5, though of slight insecticidal activity themselves, rendered DDT toxic to DDT-resistant houseflies. The required solubility in kerosene was greatest in those compounds having an alkyl radical longer than C_4 but the "intrinsic synergistic activity" was greatest in the methyl members. An important result is that DDT dehydrochlorinase was shown to be inhibited *in vitro* by one of the more active of the series, *N*-methyl-4-bromo-benzenesulphon-4'-chloranilide.

FIELD CROP AND GARDEN INSECTS

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There were 94 papers listed in the Agricultural Entomology section of the Tenth International Congress of Entomology, or 13 per cent of the approximately 720 papers presented during the Congress. Canadians were authors of 15 per cent and Americans of 40 per cent of the Agricultural Entomology contributions. Ten countries contributed the remaining 45 per cent. Many of the papers in the section dealt with extension entomology and tolerances. These and papers read by title are not considered in this symposium. Papers on fruit insects, though included in Agricultural Entomology, are reviewed by another speaker. Papers on field crop and garden insects, therefore, totalled 54, of which 60 per cent were contributions from American and Canadian researchers.

With the exception of one series of papers and an informal gathering that will be mentioned later, the formal presentations in the sessions on field crop and garden insects lacked the zest and exchange of ideas that apparently characterized many of the other topics discussed at the Congress. This is not surprising because papers dealing with the biology and control of insects affecting agriculture generally contain straightforward presentations of results, and the interpretation of these is not usually highly controversial. The methods employed by agricultural entomologists to arrive at their conclusions are often more controversial than the results and conclusions themselves. The Congress sessions were probably less dynamic, because of the language barrier, than most gatherings of agricultural entomologists. Furthermore, I considered that the section on field crop and garden insects did not draw its fair share of the general attendance. Some sessions were conducted with less than 20 in the audience, including the contributors. Such countries as Peru, Cuba, Rhodesia, and South America—presumably with small delegations — were usually represented. The thought occurs that the economic insect problems are of primary importance to countries such as these and, consequently, their delegations would consist mainly of entomologists anxious to learn of the more advanced methods of insect control. On the other hand, countries in which this aspect of entomology has kept abreast of developments would reduce the number of economic entomologists in their delegations and contribute more personnel to participate in more specialized sections. These thoughts may be without foundation, but they suggest a possible reason for the relatively poor attendance. It is not suggested that interest was low, only that there was a low registration of entomologists primarily interested in insects affecting field and garden crops. It would be useful for future congresses to consider the total attendance at each section and to correlate this information with the interests of the members as indicated on registration forms.

Topics on field crop and garden insects on which there were few, or no, papers and which I felt would have been well received were the potato leafhopper, systemic insecticides, and nematodes. I would consider these "negative highlight" impressions. On the other hand, the Congress left so many "positive highlight" impressions that it is difficult to single out those deserving of more comment than others. Among these were soil insects and soil insecticides, and the transmission of viruses by insects. I would also consider the post-Congress tours of southern Ontario and the financial contributions to the Congress as "positive highlights". (See p. 85.)

POTATO LEAFHOPPER

There were no papers dealing specifically with the potato leafhopper, *Empoasca fabae* (Harr.), although this is one of the most economically important insects of North America. Very little is known of the overwintering areas, migratory habits, and population dynamics of this pest, and also its role as a vector of many virus diseases. However, the economic importance and control of this pest and other insects affecting forage crops were discussed during an evening meeting of research workers on forage insects. Those in attendance at this informal meeting agreed that a great deal more work was required, particularly on the migratory and disease transmission aspects, for an adequate knowledge of the potato leafhopper. Another point brought out was the difficulty in estimating populations of insects in forage crops. Although many methods, such as the number of insects per net sweep or nymphs per number of leaves, are in common use it was the general opinion that more statistical research on the problem would aid in establishing sampling methods whereby an investigator could arrive at a reasonably accurate population estimate. The desirability of all investigators, particularly those working on co-operative projects, using a standard sampling technique was stressed. This allows for a direct comparison and avoids conflicting results that occasionally arise when different sampling techniques are used. Probably the point that evoked the most discussion was that relating to the estimation of damage attributable to one insect when numerous species are involved. Anyone who has ever swept a healthy stand of clover or alfalfa and has tried vainly to sort out and identify the captured, seething mass of insect life will appreciate that here indeed is a problem of untold ramifications. Once the manifestations of injury are known and assessed for each species, it still is necessary to translate this information into terms of dollars and cents so that the relative importance of the species can be determined. Probably in no other group of crops is the complexity of this problem so great as in forage crops. Yet until information of this nature is obtained, we lack important knowledge on a major aspect of economic insect problems. This, of course, is applicable to all our economic insects and we, as entomologists should be continually striving to assess the monetary losses attributable to insects and the monetary gains attributable to our own success in reducing insect depredations. I venture to sugest that in the field of agriculture alone these figures would be staggering.

SYSTEMIC INSECTICIDES

Though systemic insecticides have immense possibilities and have received much attention recently, only one paper was presented on this subject. J. E. Simon of Peru showed that 0.05 per cent O,O-diethyl 0-[2-(ethylmercapto)ethyl thionophosphate and 0.1 per cent O,O-dimethyl O-[2-(ethyl-mercapto) ethyl thionophosphate effectively reduced the population of *Empoasca* spp. on cotton, the latter having a longer residual action. Against the cotton or melon aphid, *Aphis gossypii* Glov., these two compounds were superior to other systemics tested, although approximately 50 per cent O,O,diethyl S-(ethylthiomethyl) phosphorodithioate incorporated into the soil gave excellent control. However, the reported rate was approximately 38 pounds of active ingredient per acre, which is 20 to 40 times greater than that recommended; unfortunately the language barrier prevented a discussion which may have clarified this point.

Dr. W. A. Rawlins of the United States, in his general paper on seed treatments, touched briefly on systemic seed dressings that control such insects as leafhoppers, mites, thrips, and aphids for 6 to 8 weeks after the seedlings have

emerged. The advent of systemic seed dressings as an aid in man's constant war against insects is a remarkable advance. These dressings are still in their infancy and many problems have yet to be solved. Once perfected, they are almost certain to be received enthusiastically by cost-conscious growers, for they offer numerous advantages over the present conventional methods of controlling insects.

NEMATODES

It came as a surprise and disappointment that there were no papers on nematodes. We are becoming increasingly aware of the close association between entomology and nematology in our studies of field crop and garden pests. It is common, at least in Canada and America, to have papers on nematodes presented at gatherings of entomologists even though the subject is non-entomological; this would seem like a logical trend.

SOIL INSECTS AND SOIL INSECTICIDES

The emphasis placed on papers dealing with soil insects and soil insecticides reflected the expanding research in this field. Of the 54 papers in field crop and garden entomology, 10 were on soil insects or soil insecticides. Five of these contributions were from America, four from Canada, and one from England.

Many soil insects, which until very recently were practically uncontrollable, have been made almost impotent within the past decade. This, of course, has been possible because of the large number of insecticides that have been discovered or synthesized since the insecticidal properties of DDT were demonstrated in 1939. More notable than others as soil insecticides are the chlorinated hydrocarbons. Incorporating these into the soil as broadcast or row treatments, or adding them to the planting water of crops such as tomatoes, or using them as seed dressings reduces damage by soil insects to a non-economic level in many crops.

The papers on seed dressings were most interesting to me because of my interest in this method of soil insect control. There is something about seed dressings that is fascinating and incomprehensible. That seed dressings are effective cannot be denied. But how do they work? Consider these two examples, both of which give some idea of the potency of the chemicals we are handling today.

In southwestern Ontario onion seed is treated with half an ounce of insecticide per pound of seed for maggot control and the seed is planted as early in April as soil and weather conditions permit. There are approximately 120,000 onion seeds in a pound. An even coverage of the insecticide would give 1/240,000 of an ounce per seed. This minute quantity gives adequate protection from the onion maggot, *Hylemya antiqua* (Meig.), for 6 to 8 weeks *after* the seedling has emerged, for it is only towards the end of May that protection against maggots is first required. Similarly, to control the seed-corn maggot, *H. cilicrura* (Rond.), in field beans, ¼ ounce per bushel of one of numerous insecticides is effective as a seed dressing. This, in effect, is approximately 1/480,000 of an ounc per seed. By stretching the imagination one might expect control if this amount were concentrated at one point and if a maggot attacked the seed at that particular point. But this incredibly small amount envelops the entire testa so that the amount at a given point is infinitesimal. Remarkable as these examples are, the fact remains that the onion maggot and the seed-corn maggot are effectively controlled with seed dressings.

There are other interesting problems, perhaps not as perplexing as the one cited, associated with seed dressings. The use of seed dressings containing both

a fungicide and an insecticide rather than only an insecticide is now widespread and undoubtedly will continue to gain in popularity. Experiments in many parts of the world have repeatedly shown that where maggot infestations are present the seed can only be protected when a fungicide-insecticide combination is used. There is obviously a complementary relationship between the two components. A seed dressing containing an insecticide alone usually results in an increased stand but the increase is inadequate for commercial purposes. Occasionally, however, a seed dressing containing an insecticide alone results in a stand of fewer plants than in the untreated check. This is more noticeable during wet, backward springs when the soil temperature remains low during the germination period. This suggests that rather than protecting the seed the insecticide has had a deleterious effect on it. It has been shown that antibiotic species of bacteria exist on the seed of certain cereals and that these protect the seed from invasion of soil pathogens. Is it not possible that a similar condition exists on bean and corn seed, for instance, and that an insecticide inactivates or reduces the potency of the antibiotic species but does not prevent the invasion of soil pathogens?

Entomologists have solved many of the immediate problems relating to seed dressings, but for every one solved a new one, somewhat more complex than its predecessor, seems to be created. There was general agreement among research workers from Germany, America, England, and Canada that we are still some distance away from an adequate understanding of the exact role seed dressings play in the control of soil insects and diseases.

In addition to the papers presented, interested researchers held an informal but zestful meeting on soil insects, with special emphasis on maggots and wireworms. Dr. K. M. King of Canada was chairman of the meeting, which was attended by approximately 20 members. Each individual identified himself and briefly outlined the problems he was studying, the results achieved, and the problems still to be solved. Problems that individuals thought peculiar to their own work took on a global flavor and this, of course, enriched the discussions that followed. It soon became apparent that, as a group, soil insects are among the most difficult to study. Much of the discussion centred around the effects of soil insecticides on the soil insect fauna. The problem here is that we have been applying insecticides to the soil to control one or two species and the results are interpretable only in relation to the species concerned. Little or no regard is paid to the effects the insecticides have on the other species present, many of which would be beneficial. There is a complex relationship of numerous factors and it is difficult to envisage the ultimate effects that repeated applications over large areas will have on the entire biota. Certainly there is no dearth of future projects in this field.

Like the forage insect research worker, the soil insect research worker is aware of his shortcomings in such matters as sampling techniques for estimating insect populations; identifying the species and estimating the losses attributable to each; the host, predator, and parasite relationships; and correlating biological activity with numerous weather phenomena. These and many other aspects were discussed in a meeting at which by far most of the questions asked could not be answered satisfactorily.

TRANSMISSION OF VIRUSES BY INSECTS

The series of papers that stimulated the most interest was the symposium on transmission of viruses by insects. The contributors were Drs. E. S. Sylvester, L. M. Black, J. H. Freitag, K. Maramorosh, and J. N. Simons of the United States, M. A. Watson of England, and M. F. Day of Australia – all recognized

authorities in their field. As I cannot comment critically on the papers, the brief summary that follows is based entirely on the authors' abstracts.

Sylvester held little hope for the control of aphid-borne viruses in the near future because it is next to impossible to eliminate aphids from any general crop area. The task of control, therefore, is to prevent the aphids from feeding on the crop to be protected or prevent the aphids that do feed from becoming infective. Modification of epidermal tissues of plants to make them unpalatable would stop the spread of the semi-persistent or the persistent viruses and, if the tissues could be further modified so that they were incompatible with the virus and introducing agent, the plants would be protected from the nonpersistent viruses.

Morphological and serological studies by Black in Illinois indicated that the New Jersey potato yellow-dwarf virus and the wound-tumor virus are not closely related, although they were originally placed in the same genus, *Aureogenus*, and have some vectors in common. His studies further showed that different viruses can be transmitted by the same species of leafhoppers. The need of more critical taxonomic studies in determining the relationships of viruses to their leafhopper vectors was emphasized.

According to Freitag, mandibulate insects, beetles and grasshoppers mainly, transmit ten or more plant viruses, mostly of the mosaic type. Contrary to the recently held theory that the transmission of viruses by mandibulate insects is mechanical from plant to plant via the mouth parts, Freitag has recovered active virus from the blood, crushed bodies, regurgitated fluid, and faeces of beetles. His evidence suggests a more complex relationship between mandibulate insects and viruses than had been hitherto suspected.

The mechanism of transmission of viruses by mosquitoes was outlined by Day. By the first method, exemplified by the viral encephalitides, the virus is ingested during a blood meal, multiplies in the mosquito, and is then injected into a host in the saliva. There is no evidence that the mosquito suffers any ill effects from the virus. The pox viruses, on the other hand, are transmitted mechanically via the stylets after the mosquito has fed on an infectious lesion containing approximately 10^7 infectious particles per gram.

By exposing the upper and lower surfaces of leaves to ultraviolet radiation, Watson inactivated henbane mosaic in the epidermal tissues but not in the deeper tissues. The infectivity of the expressed sap from the deeper tissues was decreased by about one-fifth and it was, therefore, concluded that the virus is concentrated in the epidermal tissues. However, not all viruses, even though concentrated in the epidermis, are carried by aphids. The properties that enable a virus to be transmitted by an aphid are very obscure, and Watson suggests that the answer may be found in a portion of the virus particle having the ability to unite with a component part of the aphid's feeding mechanism.

In a series of neat experiments on the leafhoppers *Macrosteles fascifrons* (Stal) from the U.S.A. and *M. laevis* (Rib.) from Europe, Maramorosch showed that only the former transmitted the aster yellows virus. Carrying the experiments further, he demonstrated by rearing techniques that the two forms, which together have been referred to as the *M. fascifrons* complex on the basis of male genitalia, are sibling species and hence suggested that the taxonomic criteria for the identification of the Cicadellidae are inadequate.

Simons reasoned that, since alate aphids are the principal vectors of the non-persistent potato virus Y, factors that would alter the flight patterns of the aphid vectors would be reflected in the degree of infection of the host plant.

His experiments showed that (a) spraying the host plant, peppers, with parathion and demeton did not reduce the virus spread, (b) spraying the source of inoculum, nightshade, with parathion reduced the total incidence as well as the distance the virus was carried, (c) sunflower barriers between the peppers and nightshade reduced transmission by about one-half and that (d) spraying the barriers with demeton further reduced transmission.

This symposium attracted the largest audience and evoked the most discussion. The subject is more controversial than others covered in the field crop and garden entomology sessions. It was a refreshing symposium that brought many of us up to date on an extremely important aspect of entomology.

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MEDICAL AND VETERINARY ENTOMOLOGY

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Three symposia and 59 papers comprised the program of the Medical and Veterinary Entomology Section. The papers, for the most part, were well prepared and read. Almost every aspect of the diverse field was touchd upon, and a majority of the papers were of wide interest or implication. Symposia and review papers were generously employed to treat subjects that required a critical review.

A full appreciation of the program must await the publication of individual papers in the *Proceedings* and elsewhere. Novel observations, techniques, and concepts require careful study for appreciation of their full significance. Appreciation of the significant contributions is dependent upon thorough knowledge, experience, and understanding of all aspects of our field. I cannot profess to this backgroutnd, and would prefer, therefore, to restrict my remarks to highlights and present them from the viewpoint of a Canadian entomologist.

Symposia were the focal points of the program. These were three in number: one on the entomology of filarial infections; another on animal viruses in arthropods; and a third on the biology and control of black flies. Reference will be made to each of these subjects, and to several papers read in the general sessions.

FILARIAL INFECTIONS

Gordon (England), one of the leading authorities on the entomology of filarial infections, read a paper by Lavoipierre *et al* that was the outstanding contribution to the symposium. The paper reviewed the literature on the development of medically important filariae in their vectors, and presented their findings on the host-parasite relationship between *Loa loa* and its main vector, *Chrysops silacea* Austen. An important factor in the filaria-vector relationship is the ingestion of the filariae by the vector. Gordon and his co-workers have investigated the ingestion of the filariae for a number of year and have published several papers on the subject. A highlight of the program was Gordon's presentation of a motion picture, produced during that study, on the process of feeding by mosquitoes and tsetse flies on the tissues of rodents. The motion picture,

together with a similar film shown by Geigy (Switzerland), was an excellent technical production and an invaluable aid in the interpretation of the processes involved in feeding.

ANIMAL VIRUSES IN ARTHROPODS

Chamberlain reviewed the current status of research on arthropod-borne encephalitides in the United States. The virus-vector-host relationships, including the development of viruses within mosquitoes, and the quantitative relationship between vertebrate viremia and susceptibility of mosquito vectors, were outlined. The epidemiologic implications of the feeding specificity of mosquitoes, of immune response in host populations, and of man-made mosquito hazards were also discussed.

Man-made mosquito hazards, and their epidemiologic implications, are assuming increasing importance for the Canadian entomologist, especially in Western Canada, where the acreage of irrigated land is increasing annually. West referred to this situation in his report on the knowns and unknowns in arthropod-borne animal viruses in Canada. The unknown potential vector ability of numerous species of biting flies, and factors favouring the introduction of arthropod vectors, as well as those favouring the increase of indigenous known or potential vector species, were presented as reasons for the whole problem warranting immediate attention. It was also pointed out that the literature contains only fragmentary references to arthropod vectors of western equine encephalomyelitis, Colorado tick fever, and coxsacki viruses. The possible occurrence of St. Louis encephalitis and eastern equine encephalomyelitis must be anticipated.

Aitken described the collection and processing of arthropods in Trinidad for studies on their taxonomy, life-history, and ecology, as well as for virus studies. The experimental transmission of yellow fever by oriental strains of *Aedes aegypti* (L.), and the survival of mouse poliomyelitis virus in living vertebrate hosts, were reported by Philip and by Woke and Rosenberger, respectively.

BLACK FLIES

Black flies are of greatest medical importance in Africa, Mexico, and Central America, where they are the vectors of onchocerciasis, a disease in humans caused by filarial worms. The flies are not known to transmit any diseases to humans in North America. However, their blood-sucking habits make them a serious pest of man in many regions of the continent. Several species are important pests of livestock, and one species has caused serious losses of cattle on the Canadian prairies. Black flies have been the subject of intensive study since World War 2, and it was appropriate that the third symposium was devoted to a discussion of their biology and control.

One of the most notable contributions in the study of black flies was made by Dalmat, who conducted an investigation of the simuliid vectors of onchocerciasis in Guatemala. He established that six species of black flies attack man in Guatemala, and that three species are the most important vectors. The six species each preferred certain breeding habitats or types of streams. Dalmat's description and classification of stream types (e.g., infant, young, and mature) have found useful application in studies conducted elsewhere in the world.

Peterson and Wolfe referred to Dalmat's classification of streams in their review of the studies on black flies conducted in Canada. The review summarized extensive studies on distribution, seasonal succession of species, factors affecting

development, assessment of larval and adult populations, laboratory rearing, dispersal of larvae and adults, host reaction and immunity to bites, and many other aspects. The studies on host reaction and immunity provoked a prolonged discussion between Wolfe, Gordon, West, and D. M. Davies that concerned the reactions and immunity to the bites of other biting flies. The divergence of views made it clear that this important subject warrants detailed investigation.

Fredeen elaborated upon his contribution to the study of black flies in Canada, in a description of the 25 species that have been recorded on the Canadian prairies. One species, *Simulium arcticum* Mall., is a serious pest of livestock. Fredeen reviewed the factors contributing to the development of this species in large numbers and its dispersal for long distances from its breeding places. Three other notable Canadian workers, Ide, Twinn, and Davies, presented the results of a long-term study from which they have compiled maps of isophanes for the dates of emergence for the common species in Canada.

D. M. Davies reported his observations on the feeding and reproduction of black flies. Twenty-four Canadian species can be separated into five types, based on the maturity of eggs and quantity of stored nutrient at the time of emergence, and on the presence of piercing mouthparts in the adults. Davies suggested that the four types differ in mating behavior, and in the requirements and sources of blood meals.

L. Davies has applied D. M. Davies' criteria of the amount of stored nutrient, and the presence or absence of relict eggs, to a study in England of the differences in the behavior of young and old females of *S. ornatum* Mg. in the field, and of seasonal changes in the age-composition of black-fly catches off cattle. The speaker reported that environmental factors controlling activity affect young and old flies differentially. Flies that had not obtained their first blood meal were considered to be young. Old flies had previously obtained a blood meal.

Lewis, in a study of *S. damnosum* Theo. in Sierre Leone, found by observations on the condition of the fat-body, the peritrophic membrane, and the meconium, that he could usually determine from the condition of the ovaries and oviducts, whether the flies were parous or nulliparous. Field observations showed that most of the flies biting in the afternoon were nulliparous. It was then confirmed that the average infection rate in these flies was lower than in those biting in the morning.

The effectiveness of DDT in the control of black-fly larvae was first reported by Fairchild and Barreda in 1945. The general adoption of this insecticide for the control of both larvae and adults was reported at the Congress by several speakers. Dalmat achieved control of larvae in Guatemala by applications of DDT at 0.1 p.p.m. for 30 min., or 3.0 p.p.m.-min., in streams with volumes of 100 to 4500 gal. per min. In larger streams, 0.1 p.p.m. for 60 min., or 2.0 p.p.m.-min. were required. Peterson and Wolfe reported that the dose recommended by most Canadian workers was 0.1 p.p.m. for 15 min., or 1.5 p.p.m.-min. Fredeen has directed the annual program in Saskatchewan for the control of pest species on rivers with volume flows of up to 64,000 cu. ft. per sec., with applications of DDT at 1.5 p.p.m.-min. A single application has been effective for as far as 115 miles downstream. Fredeen and his co-workers have shown that the DDT is associated with the suspended solids in the water and that these solids are ingested by the larva. This finding may account for the heavy doses that Dalmat was required to apply in Guatemala.

Barnley, in 1952, obtained control of *S. damnosum* breeding in a 42-mile stretch of the Victoria Nile, by ten applications at weekly intervals of DDT at 1.2 p.p.m.-min. Following the treatment, the adult fly count declined from over

100 flies per boy per hour to zero. A practical degree of control persisted for over three years, the vector failing to repopulate the breeding sites. The significance of this achievement was evident when it was reported that, before the control measures were applied, the incidence of onchocerciasis in villages within 5 miles of the Nile was 80 per cent and all permanent residents over 30 years of age were infected. Barnley has now organized a program for the control of the other important vector in Uganda, *S. neavei* Roubaud. This species breeds in streams on forested mountain slopes.

Extensive studies on the biology and control of black flies have been in progress in New York State since 1945. Collins and Jamnback described the 10-year program of control experiments, which have resulted in the adoption of control measures by 10 separate communities. Larvicides have been applied from aircraft and from the ground. DDT-impregnated blocks of plaster of paris, placed in individual streams, have been shown to be effective and practical. Aerial applications of DDT solutions at doses as small as 0.1 lb. of DDT per acre are employed for the treatment of large areas for larval control. Aerosol generators and mist blowers dispersing a DDT solution are employed for the control of adult flies.

Peterson and Wolfe described the promising results against black flies obtained on the north shore of the St. Lawrence River by the treatment of sections of a drainage basin. A DDT solution was applied from aircraft in flights across the basin and along parallel lines at one-quarter mile intervals to give average doses of 0.02 lb. and 0.1 lb. of DDT per acre. Promising results were also reported in the control of adult flies by the aerial application of a DDT solution at 0.25 lb. of DDT per acre. In this case, the aircraft was flown on parallel lines at 200-yd. intervals to cover an area of 7 sq. mi.

TICK PARALYSIS

Gregson and Murnghan described two phases of an investigation in progress in Canada on tick paralysis caused by *Dermacentor andersoni* Stiles. With the aid of excellent drawings and photographs, Gregson described the structure of the capitulum in *D. andersoni* and outlined the nature and function of the hypostomal groove, the oral aperture, and the pharyngeal valve. He clarified the mechanisms of attachment, feeding, and detachment, as well as the course and flow of the salivary secretion and its probable relation to the production of paralysis.

Murnaghan (Canada) is investigating the nature and cause of the paralysis. He reported that it is due to a failure of transmission at the neuro-muscular junctions and in the spinal cord synapses, and results from decreased liberation of acetylcholine at these sites. However, he showed that curare-, decamethonium-, and magnesium-like actions can be excluded as the cause of the paralysis.

CATTLE GRUBS (*HYPODERMA* SPP.)

Recent life-history studies on cattle grubs in Western Canada were reviewed by Gregson. Methods of girdling cattle for the collection of grubs were described, and data were presented on seasonal development and mortality of hypodermal larvae, and on the emergence, dispersal and mating of adult flies. Rich, a participant in the studies reviewed by Gregson, elaborated upon his investigation of some of the factors affecting populations of *Hypoderma* species, in a paper read for the author by Gregson. A *Hypoderma* population in a large herd of cattle was studied through three successive generations. In addition to reporting upon observations on the influence of behavior characteristics of individual animals,

and the natural mortality of hypodermal larvae and the pupae, Rich demonstrated that randomization is essential in the selection of the sample group. An examination of published reports will indicate that this factor has not received sufficient consideration in many studies on the biology of cattle grubs, and on the assessment of control measures.

Weintraub, who has also played a leading role in the studies conducted in Western Canada, recently induced *H. lineatum* (De Vill.) to mate under laboratory conditions. The simple technique, in which the adults are suspended from threads and permitted to come in contact while flying, has opened the way for new studies on the life-history of *H. lineatum* and the complex host-parasite relationships. Weintraub has made other significant contributions as a result of his laboratory study of the mating, oviposition, and other activities of the adult flies.

SENSORY ORGANS OF BITING FLIES

A functional interpretation of the sensory organs of the biting flies has been eagerly awaited by those interested in the behavior of these insects, and particularly by those engaged in research on repellents and attractants. The challenge of this complex study was accepted by Scudder, who presented his observations and interpretations for the consideration of the members. Scudder appeared to have concentrated his efforts on the tabanids, but the published paper is expected to include similar studies on mosquitoes and other biting flies.

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PHYSIOLOGY AND BIOCHEMISTRY

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An international scientific Congress should afford a condensed view of the trends and frontiers in that science, discernable because of the condensation. Scientists have as much affinity for the band wagon—for the new and exciting—as any other group, so that even the number of papers on any one topic affords an index of current interest. Not always, of course, for sometimes a single paper has established a new frontier on the spot. I do not think the Entomology Congress was distinguished in this way, at least not in the Physiology and Toxicology Section. Williams' isolation of the juvenile hormone was the closest candidate but it was foreshadowed by much work indicating the existence and function of such a hormone. Nevertheless, while there was, I think, no sharp spearhead, the broad frontiers of insect physiology and biochemistry were clearly defined.

One trend may be indicated by the statistic that in the Section devoted to Physiology and Toxicology, only 14 of the 81 papers presented dealt with Toxicology. Distinguished toxicologists such as Chadwick and Kearns have repeatedly stated their view that the central problems of insect toxicology — resistance and mode of action—will yield more readily to an approach through a broader understanding of insect physiology than to a frontal attack. If the Congress program offered a fair sample, this point of view is being supported.

Of the papers dealing with toxicology, about half dealt with the problem of insect resistance to insecticides. This focus of interest was not surprising, of course. What was surprising was the relatively little emphasis indicated.

There was clear recognition of the special place of hormonal phenomena in insect physiology, as indicated by Dr. Martin's review of the Congress. Interesting, too, I thought was the emphasis on the isolation and identification of these strange substances—ecdysones, juvenile hormone, sex attractants; we are no longer satisfied to deduce their presence by parabiosis or transplant experiments.

Another front was recognized by the 12 papers dealing with neurophysiology. This subject provides a meeting place for physiology and toxicology because derangement of nervous function is involved with many insecticides, especially clearly with the organophosphates. But here, too, the emphasis was on the normal physiology of nervous function, the insecticides often being introduced as tools to facilitate an understanding of the physiological events.

Finally, I think the Congress afforded a view of the emergence of insect biochemistry. One symposium was devoted to metabolic processes in insects. There are still relatively few workers in this field and, it must be said, some of the work reported was disappointingly superficial. But the trend is clear—many of the problems of insect physiology, nutrition and toxicology will require biochemical methods for their elucidation. This development has been recognized elsewhere. At the September meeting of the American Chemical Society, a symposium on Insect Biochemistry was instituted. There are plans also to establish a Section on Insect Biochemistry at the next International Congress of Biochemistry.

GENERAL PHYSIOLOGY

From the papers on aspects of general physiology, I have selected for comment three dealing with the strange phenomenon of discontinuous respiration in insects. The observation that carbon dioxide is released in bursts was first made by the Dutch worker Punt, and rediscovered by Schneiderman using *Cecropia* pupae. A nice background for these papers was provided by Beckel who reported on his work dealing with the structure and function of the spiracular closing mechanism. Schneiderman presented his evidence that respiratory carbon dioxide is retained and released in bursts. Oxygen uptake, however, appeared to be continuous. Yet, both CO_2 release and O_2 uptake occur through the spiracles. He suggested that high internal CO_2 tension and low O_2 tension cause the closer muscle to relax and the spiracular valve is then opened by the elastic opener described by Beckel. Isolated spiracles also respond to CO_2 and O_2 in the same way, but normal coordination seems to be in control of the central nervous system.

Buck addressed himself to the anomaly of the apparently continuous O_2 uptake despite the observed discontinuity of spiracular opening associated with the CO_2 release. He presented data to support the hypothesis that the valve is not completely closed—that a minimum spiracular opening can exist which will impound the CO_2, because of its solution in the blood, and yet not interfere with O_2 uptake. He calculated that the CO_2 concentration in the tracheae increases from about 6% to 20% during the interburst period and before the closer muscle is induced to relax. The rather amusing sequel to this story is that Punt has now re-entered the field and has shown, in a paper appearing after Congress, that when sufficiently sensitive methods are used, both CO_2 release and O_2 uptake are shown to be discontinuous and synchronous!

BIOCHEMISTRY

The papers dealing with insect biochemistry did not conform with any overall theme and, in the main, left the impression that we are still in the exploratory stages. However, two papers were outstanding. One by Chefurka reported the most detailed account of glycolysis in insects yet available. Besides the DPN-linked glycolytic pathway for carbohydrate metabolism, Chefurka has outlined an alternate TPN-linked pathway from glucose-6-phosphate to CO_2. This pathway, which was demonstrated in house-fly flight muscle, is particularly interesting because it is potentially capable of yielding more energy than glycolysis and because it avoids lactate production—useful attributes in such a highly active tissue. Chefurka's work was particularly convincing because of the evidence of stoichiometry in his reactions. Of biological interest was his finding that, during the pupal-adult transformation, there is a shift from the anaerobic glycolytic system to a system using both pathways for carbohydrate metabolism.

Wyatt presented a paper on the organic components of insect haemolymph and showed that the principal carbohydrate was the exotic sugar trehalose. This sugar was present as 80 to 95% of the total free sugar, while glucose was a minor constituent. He has evidence that trehalose is widely distributed among insects. Nothing is yet known about its metabolism except that a degrading enzyme is present. Of the phosphorous-containing components, phosphorylcholine was the largest component and occurred in quantities up to 300 mg. percent. Since phosphorylcholine has been shown to be involved in the synthesis of acetylcholine, this finding may be significant because of the extraordinarily high acetyl-choline content of insect nervous tissue. Wyatt's findings add further evidence for the generalization that insect haemolymph differs greatly in composition and metabolic role from the plasma of vertebrates.

NEUROPHYSIOLOGY

At the risk of appearing chauvinistic, it must be said that the work at the London laboratory contributed notably to the discussions on neurophysiology! This work was reviewed by myself and presented in individual papers by O'Brien, Calhoun and Fisher. Briefly, our work has provided convincing evidence for the presence of acetylcholine in insect nervous tissue and shown that the enzymic mechanisms for its synthesis occur also. Evidence that the physiological function of acetylcholine in insects, as in vertebrates, is that of a synaptic mediator has been provided by the demonstration that it is released and accumulates during nervous activity. Furthermore, in insects treated with anti-cholinesterases, the acetylcholine levels increase greatly in accordance with theory. Finally, the demonstration of a barrier impermeable to acetylcholine has resolved the anomaly of the insensitivity of insects to this and related substances. These various studies lend support to the classical interpretation of nervous function based on the ACh system, and indicate that this system affords the best present basis for interpreting the toxic action of organophosphorus insecticides in insects.

In other papers, and during discussions, it was pointed out that certain anomalies between the insect and mammalian nervous systems still remain. Wigglesforth stated that he had used a histochemical method for the localization of ChE and had been unable to demonstrate the enzyme at neuro-muscular junctions in insects, whereas in mammals there is a specific concentration at these sites. Smith presented the anomalous situation in insect eggs, where parathion applied in the early stages of embryonic development, and before ChE activity is detectable, is still lethal. After exposure to parathion, the eggs continue to develop up to the time of hatching and then die. ChE activity appears late in development and Smith suggests that the inhibitor is somehow stored and re-

mains available to inhibit the enzyme when it normally appears. Twarog presented results showing that when the outer sheath is stripped from insect nervous tissue, the effects of external K and ACh is potentiated. Her findings, linked with those of Hoyle, O'Brien and Calhoun, indicate that the nervous system of insects is isolated and protected by a tissue barrier or barriers.

Van der Kloot has related these events to the phenomenon of diapause. At the outset of diapause, the brain of *Cecropia* pupae becomes electrically silent and can no longer be excited. At the same time, the ChE activity disappears. When diapause is broken, ChE activity is restored, the brain again becomes excitable, the neurosecretory cells release their hormone and diapause ends. Using frog muscle, Van der Kloot showed that ChE inhibitors reduced the resting potentials to about the same degree as in diapausing *Cecropia* brains. Thus, loss of ChE activity is associated with lowered resting potentials which in time may inactivate the neurosecretory cells, enforcing pupal diapause.

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III. SCIENTIFIC NOTES AND COMMENTS

MICROSPORIDIAN INFECTIONS IN ONTARIO BLACK FLIES

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Parasitism of simuliid larvae by several microsporidian genera in various parts of the world has been reported in the literature. Strickland (3, 4) was the first to discuss this parasite of black flies in North America. He found from 1-80% of the larvae of *Prosimulium hirtipes* (Fries) infected in various streams near Boston, Massachusetts. Cameron (1) stated that near Saskatoon, Saskatchewan, a few larvae of *Simulium bracteatum* Coq. (= *aureum* Fries) and *S. vittatum* Zett. were infected with microsporidia and Wu (6) said that occasional larvae of *S. vittatum* contained this parasite near Douglas Lake, Michigan. In the region of Ottawa, Ontario, microsporidia were found by Twinn (5) from April to September in the larvae of several species including *P. hirtipes, S. vittatum* and *S. venustum Say*. He found the percentage of infected larvae usually small, the highest observed being 24.5%.

The present study was conducted during 1947, 1952 and 1953 in streams in Algonquin Park and in Spencer Creek near Hamilton. In Spencer Creek only *S. vittatum* larvae were seen to be infected and most by *Thelohania bracteata* (Strickland). In Algonquin Park, *S. venustum* and *S. decorum* Walker appeared to be parasitized by this species, and *S. venustum* also by *T. fibrata* (Strickland). Two other species, *T. multispora* (Strickland) in *S. vittatum* and *C. dacotensis* (D. and S.) and *Caudospora* sp. in *P. hirtipes,* were less common in the Park. The microsporidia were identified by Dr. E. A. Steinhaus and Mr. K. M. Hughes of California and some of these associations were published earlier (2).

Larvae infected with microsporidia were observed from May 12 to October 11 in Algonquin Park. From May 13 to June 28, 1947 in Costello Creek in the Park about 3% of 1393 larvae examined macroscopically showed the spore stage of this parasite. In June, 1952, in streams on the Madawaska watershed in the Park, the infection varied from 1-10% but this dropped to less than 1% by August and to even less by October. On each of several days in the spring and summer of 1953, 25 larvae were collected randomly from Spencer Creek and their body contents smeared on slides, stained and examined microscopically. The infection rose from 4% on May 4 to 36% on June 16 and 16% on July 14. Four other collections taken during this period, showed no infection as did nine collections taken from July 27 to September 15. Also in this latter period no infections were seen macroscopically in several collections of 100-300 larvae.

This parasite usually inhibits the development of the pupal histoblasts so that the larvae grow to large size and seldom, if ever, pupate. The infected larvae are found in slower currents and die more quickly in the laboratory than the average healthy-appearing larva.

From the preliminary observations made in Ontario, it is considered that microsporidia are usually of minor importance in the natural control of black flies.

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MALATHION IN CONTROL OF LEAF MINERS* ON ARBORVITAE

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In 1955 arborvitae hedges and trees in the Guelph, Ontario area showed considerable browning of tips and even small branches. Examination of 500 samples showed 92 per cent of the injury was caused by leaf miner activity.

Preliminary experiments indicated that the use of malathion might provide effective control. The insecticide was applied at the rate of 4 pounds of 25 per cent wettable powder to 100 gallons of water on August 4, 1955.

Samples of infested leaves from each of five sprayed areas and three unsprayed areas were collected and examined during the month of August. Each sample consisted of the infested leaves from one square foot of hedge. Samples were chosen at random from one of three levels.

A summary of results is given below.

Results of a Single Malathion Spray

Sprayed Area	Living	Dead	Unsprayed Area	Living	Dead
1	9	115	A	90	8
2	0	88	B	190	5
3	1	75	C	198	3
4	1	68		—	—
5	1	44		478	26
	—	—			
	12	390			

Sprayed Areas—97.1% mortality
Unsprayed Areas—5.2% mortality

The areas were examined during the fall of 1955 and the summer of 1956. There was no evidence at any time of phytotoxicity.

Light leaf miner injury in 1956 made spray experiments impractical.

**Argyresthia* spp. (Family Yponomeutidae. Order Lepidoptera)

NOTES ON THE BOXELDER BUG: LEPTOCORIS TRIVITTATUS (Say)

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Increasingly severe infestations of this insect have occurred during the past few years in a number of areas in southwestern Ontario.

Preliminary studies on control were begun in 1956. Most of the work was carried on in Brantford, Ontario.

It is commonly stated, for example by Craighead (1) and Herrick (2), that eggs are laid on boxelder in the spring. Herrick mentions that eggs are also laid in out-of-the-way places, but assumes that nymphs hatching from these are "probably unable in most cases to survive".

The author observed somewhat different habits during the summer of 1956. Further study is necessary to determine whether these observations represent the usual behaviour pattern of the species in southwestern Ontario.

Eggs were found in the latter part of June and throughout the summer on weeds, tree seedlings, long grass, and even on wooden fences. Various instars also were found in similar locations, and were observed feeding on a variety of plants.

No eggs or nymphs were found on Manitoba maple (*Acer negundo* L.) before the fifteenth of August in any of the areas visited, including Brantford, Forest and Acton. After that date nymphs and adults frequently were found on seed-bearing Manitoba maples.

(1) **Craighead, F. C.** (1950). Insect enemies of eastern forests. U.S.D.A. Misc. Public. No. 657.
(2) **Herrick, G. W.** (1935). Insect enemies of shade trees. Comstock.

THE BLACK WIDOW SPIDER, LATRODECTUS MACTANS MACTANS (FABR.) IN BRUCE COUNTY, ONTARIO

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The black widow spider has been recorded from several widely scattered localities in Ontario—Point Pelee, Turkey Point, and Sydenham[1]. According to O'Rourke[2] it also occurs at Sarnia and Nipigon. The Nipigon record is questionable and certainly needs corroboration. In 1952 a few immature males were collected in the vicinity of Dyer Bay situated on the peninsula separating Georgian Bay and Lake Huron. Observations in 1954 and 1955 revealed that they were abundant in that area. Cracks and crevices in the limestone outcroppings and cavities under rocks on the surface of the ground were favoured haunts of the females.

The main sources of food for the black widow females appeared to be field crickets and various species of shorthorn grasshoppers. It was of interest to note that large, powerful beetles such as June beetles (*Phyllophaga* spp.) and the Fiery Hunter (*Calosoma calidum* Fabr.) were commonly found in the webs or among the discarded insect remains below. Spiders were observed in the outer parts of the web during the early part of the morning only. Throughout the remainder of the day they could not be enticed from the deep retreats of their web. The struggling of crickets and grasshoppers thrown into the webs failed to attract the spiders within.

There have been no reports on persons being bitten by the black widow in this area in spite of the large numbers of spiders present.

1. Communication from Dr. F. Urquhart—Royal Ontario Museum, Toronto.
2. Processed Publication 127, Entomology—Canadian Department Agr., Sci. Service, Ottawa.

IV. REVIEWS AND REPORTS

XTH INTERNATIONAL CONGRESS OF ENTOMOLOGY. SOME FINANCIAL CONTRIBUTIONS FROM ONTARIO.

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The unenviable task of raising the substantial funds necessary to operate the Congress was left in the very capable hands of Mr. A. B. Baird and Mr. W. N. Keenan, Canada Department of Agriculture, Ottawa, who were chairman and vice-chairman, respectively, of the finance committee. Mr. G. F. Manson, officer-in-charge of the Chatham laboratory, and I were assigned much of the area of southern Ontario to canvass for funds. We considered as likely prospects those individuals or companies who we thought had benefited in the past, or would in the future, from the results of our entomological research. Inexperienced as we were, it was with some reluctance that we approached our prospects, first by letter and then by personal contact. The enthusiastic reception that our solicitations received was a revelation and a very pleasant surprise to us. Contributions of $25.00 from small seed stores to $500.00 from large canning companies were generously given. Thus it was that from a very small area in Canada we collected just slightly less than $4000.00. The amount is not so surprising as the attitude with which it was given. The feeling was frequently expressed by donors that they considered it not only a pleasure but an obligation to support the Congress because of the benefits entomology had brought them. When a profession such as ours enjoys the financial support of these groups, how much more so do we enjoy their moral support? It is a comforting thought.

XTH INTERNATIONAL CONGRESS OF ENTOMOLOGY. POST-CONGRESS TOURS OF SOUTHERN ONTARIO.

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At the conclusion of the regular sessions of the Congress, it was my privilege to act as a guide, along with Mr. W. G. Matthewman, Entomology Division, Ottawa, for 62 delegates on an official tour of southern Ontario. Participating in the tour were 16 delegates from the British Isles, 8 from Germany, 7 from France, 7 from U.S.S.R., 4 from U.S.A., 3 from Rumania, 2 from Peru, 2 from Australia, and one from each of 13 other countries. Starting at Montreal and ending at Toronto, the tour, in two motor buses, covered approximately 900 miles in 7 days.

Entomology laboratories at Belleville, Guelph, London, Chatham, Simcoe, and Vineland were visited, as well as the departments of biology and the campuses of the Ontario Agricultural College and the Ontario Veterinary College at Guelph, University of Western Ontario, London, and McMaster University, Hamilton. Tours were also made of Macdonald College at Ste. Anne de Bellevue, Quebec, and the Royal Military College and Queen's University at Kingston, and brief stopovers were arranged at Fort Wellington Historic Park, Prescott; Old Fort Henry, Kingston; Dale Estate Greenhouses, Brampton; and the Royal Botanical Gardens, Hamilton. The delegates were also shown the impressive international power development projects near Cornwall and, of course, Niagara Falls and surrounding district. Needless to say, cameras clicked incessantly at every opportunity.

Wherever the tour stopped it was evident that those responsible for arrangements had spared no time or effort to make the visit an impressive and memorable one. Canadian hospitality was at its best. Such courteous, friendly receptions were accorded the delegates at all points that it was virtually impossible to adhere to the prepared time schedule. That the tour began and terminated on the appointed days is rather remarkable! Without exception, the delegates were lavish in their praise of our Canadian biological institutions, the work that was in progress, and the future work that was possible because of unexcelled facilities.

Also noteworthy were post-Congress visits to our institutions by those scientists who travelled singly or in small groups and whose activities were not so restricted because of a rigid timetable. The latter visits were most welcome because of their very informal nature and the complete freedom of movement and discussion that they permitted and that are possible only to a small degree with larger delegations. It would be impossible to estimate the value of these tours to Canadian entomology. The personal contacts that many of us made with our counterparts in other countries cannot but have stimulating and beneficial effects on our own research. Certainly I will remember my participation in the tour of southern Ontario long after memories of other Congress highlights have faded.

SUMMARY OF IMPORTANT INSECT INFESTATIONS, OCCURRENCES AND DAMAGE IN CANADA IN 1956[1].

C. GRAHAM MACNAY[2]

This summary of insect conditions in Canada in 1956 was prepared from regional reports submitted by Officers of the Entomology Division, Provincial Entomologists, Officers of the Plant Protection Division, Canada Department of Agriculture, and University Professors. In general, common names used are from the 1955 list approved by the American Association of Economic Entomologists. To avoid unnecessary duplication, forest insect conditions are not included, this being adequately dealt with in the *Annual Report of the Forest Insect and Disease Survey,* published by the Forest Biology Division, Canada Department of Agriculture.

GENERAL-FEEDING AND MISCELLANEOUS INSECTS

BEET WEBWORM.—At Grand Forks, B.C., beets and onions were damaged. In Alberta populations were small and damage light. In Saskatchewan, heavy infestations occurred in many flax fields for the first time in several years but damage was light. The insect was not reported in Manitoba.

BLISTER BEETLES.—These insects were reported in each of the Prairie Provinces but damage was very light.

CRICKETS.—In southern areas of Manitoba and Quebec and in eastern Ontario, notable increases occurred in populations of the field cricket.

CUTWORMS.—In British Columbia, cutworm damage in the Thompson and Okanagan valleys was much heavier than in 1955, the red-backed cutworm being chiefly responsible. The variegated cutworm severely damaged potato and garden crops at Solsqua and Grand Forks, and the bertha armyworm fed on the foliage of potato and other vegetables at Soda Creek, Kamloops, Chase, Ashcroft, and Grand Forks.

In Alberta, a survey for the armyworm revealed very light infestations and negligible damage. A light infestation of the red-backed cutworm in a field of sugar beets at Lethbridge caused the only damage reported. For the third successive year, the pale western cutworm was neither observed nor reported.

In Saskatchewan, the bertha armyworm occurred on rape and flax in the most severe and widespread infestation ever recorded in the Province. The Indian Head-Sintaluta-Glenavon area, the Semans-Earl Grey-Cupar area, and the White Fox-Nipawin-Aylsham area were the main regions affected. Local damage was reported from Birch Hills, Meskanaw, Tisdale, Holdfast, and Craik. A few fields of rape were severely damaged before control measures were applied. The red-backed cutworm occurred in greater numbers than in 1955; moderate damage occurred in the Paynton-Lloydminster-Marsden and Saskatoon areas. Garden crops were attacked at Scott and Nipawin. *Polia lilacina* (Harv.) was present in most flax fields in the central and west-central agricultural parts of the Province, but damage was negligible. The pale western cutworm was scarce and caused no damage.

In Manitoba, light damage in gardens caused by the red-backed cutworm was the only cutworm damage reported.

In Ontario, cutworm damage was generally below average. However, a few fields of corn in Kent County were severely damaged, mainly by the black cutworm. This species, together with the variegated cutworm and the dark-sided cutworm, caused light injury to tobacco in Kent, Elgin, Norfolk, and Brant counties and some severe local injury in Harwich, Howard, and Orford townships in Kent County. At Cedar Springs, strawberries were severely damaged by the dark-sided cutworm. The armyworm caused some minor, early-season damage to grain and corn in southwestern Ontario and was very scarce in the eastern part of the Province. During June and early July *Scotogramma trifolii* (Rott.) attacked cabbage to an unusual degree in the Ottawa area.

In Quebec, damage by cutworms varied from average to below average.

In New Brunswick, cutworms were numerous and injurious in many localities; many crops were attacked, especially potatoes and corn. Adults of the armyworm were numerous in July and a local concentration of larvae damaged hay at Sussex, but damage was generally light. The fall armyworm was abundant in early corn. Cutworms on blueberry were less numerous than in 1955 excepting the black army cutworm, which showed some increase.

In Nova Scotia, the variegated cutworm, the black cutworm, and species of *Feltia* and *Euxoa* occurred in moderate numbers, excepting a severe outbreak of the variegated cutworm on chrysanthemums in a greenhouse at Falmouth in November. The bronzed cutworm persisted at low population levels in grassland in the Cow Bay area. Neither the armyworm nor the fall armyworm was reported.

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In Prince Edward Island, the variegated cutworm caused below-average damage in gardens and commercial plantings of beans and cucumbers and no other species were of economic importance. In Newfoundland, the black army cutworm and the variegated cutworm occurred only in small numbers and the armyworm was not observed.

EUROPEAN EARWIG.—On Vancouver Island and in the lower Fraser Valley, B.C., this insect was extremely abundant in backyard gardens, but in the tree fruit areas of the interior a noticeable decline in numbers was noted and little fruit injury was reported. In Ontario, the pest continued to spread, mainly in a northerly and westerly direction from Ayton, where it became established a few years ago. In St. John's, Nfld., continued spread and larger numbers were noted.

GRASSHOPPERS.—In British Columbia, there was little change in grasshopper populations. However, 7,500 acres were sprayed in the Nicola Control Zone, some control measures were necessary on Pavilion Mountain, and there were heavy localized concentrations in the Vernon area. Local infestations of economic importance occurred also in the Peace River area and at Quesnel and Kersley. In the East Kootenays the few infestations were light and local. In the Peace River area and the Cariboo, *Melanoplus bivittatus* (Say) was the most abundant species, but *M. borealis junius* (Dodge) and *M. bruneri* Scudd. were also abundant in a few areas. *M. bivittatus* and *M. bruneri* required control on Pavilion Mountain; unimportant numbers of *Camnula pellucida* (Scudd.) were also present in the area. Elsewhere in the Province, *M. mexicanus* (Sauss.) and *C. pellucida* occurred in about equal numbers, but populations were so small in many districts that comparisons were difficult.

In southern Alberta, grasshopper infestations were generally light and confined to roadsides. *M. mexicanus, M. bivittatus, M. packardii* Scudd., and *C. pellucida* were present in varying proportions. There appeared to be an increase in populations, due mainly to an increase in *M. mexicanus*. In the Peace River area in northern Alberta there were light scattered infestations, mostly of *M. mexicanus* and *M. bruneri*. There were only a few isolated instances of economic loss in the Province.

In Saskatchewan, grasshoppers increased sufficiently in numbers and importance to cause appreciable demands for control materials in southern areas, chiefly from Mortlach, Glentworth, and Bengough in the south-central agricultural areas and Gainsborough in the extreme southeast. Other centres of infestation included Gravelbourg, Coronach, Minton, Torquay, Estevan, and Carnduff. Forecasted outbreaks in the extreme southwest did not develop. The adult population was the largest since the autumn of 1951, but even the heaviest infestations were considered to be of only moderate intensity. Favourable weather permitted approximately normal oviposition and the resulting area of expected economic outbreak, although still not large (about 85 townships), was the most extensive since the forecast for 1951. In the forecast areas, *M. bivittatus* was the most abundant species and *M. mexicanus* had made rapid gains; elsewhere in the central agricultural areas the latter species had increased noticeably. *C. pellucida* was present, usually in minor numbers, along with the more numerous species in the areas of economic abundance, and was most abundant in a small area near Carnduff. It was extremely rare, however, in the west-central and central agricultural areas, where major outbreaks had occurred in the last 25 years.

In Manitoba, the adult survey revealed a further increase in abundance of the economic species. Moderate to severe infestations occurred in the Brandon-Shilo, Neepawa-Gladstone-Carberry, Carman-Graysville, and Dominion City districts. On the lighter soils, alfalfa fields and pastures suffered, with marginal damage to grain crops also common. On the heavier soils, damage was largely marginal. Control measures and excellent growing conditions prevented severe damage in these areas. There was a marked build-up between adult and egg surveys in some areas and in others the ratings remained the same. The build-up was confined largely to the Red River Valley, where the increase ranged from one to two categories. A severe infestation occurred in the Carman district. This area was surrounded by a moderate infestation that extended northwest to Treherne and east and south to cover most of the Red River Valley. This entire area was surrounded by a narrow strip of light infestation. A small severe area of infestation occurred in the Dominion City district. A moderate infestation occurred north and east of this severe area, and light infestation north and east of the moderate infestation. Light to moderate infestations occurred northeast and northwest of Winnipeg. Moderate to severe infestations were present in the Neepawa-Gladstone-Carberry and Brandon-Shilo-Treesbank districts. Several small light and moderate infestations occurred in the western part of the Province. On the lighter soils, alfalfa, pastures, and roadsides were infested. *M. mexicanus* was the most abundant species on the lighter land, with *M. bivittatus* second and *C. pellucida* and *M. packardii* also present. On the heavier soils, roadsides and some pastures were infested. *M. bivittatus* was the most abundant species, with *C. pellucida* second and *M. mexicanus* also present. The forecast area of infestation for 1957 covered approximately 6,697 square miles as compared with 1,222 square miles in 1956 and represented also a sevenfold increase in severity.

In Eastern Canada, large populations of grasshoppers damaged timothy and oats in the northern part of Wellington County and in Bruce County, Ont. Populations were average to above average in eastern Ontario, and a severe local outbreak of *M. femur-rubrum* (DeG.)

damaged pasture, vegetables, and ornamentals in the Metcalfe area. In southern Quebec, this species and *Dissosteira carolina* (L.) were fairly abundant. Small populations and minor damage occurred in the Atlantic provinces.

INSECTS FEEDING ON WEEDS.—In British Columbia, moderate to severe infestations of *Trirhabda pilosa* Blake occurred again over an extensive area of sagebrush southwest of Kamloops. The infestation apparently spread northward to the Thompson River.

In Saskatchewan, a chrysomelid, *Gastrophysa polygoni* (L.) attacked wild buckwheat in grain fields throughout the central and west-central agricultural areas and in some instances caused severe defoliation for the second consecutive year. Larvae were reported from Saskatoon, Elstow, Langham, Scott, Landis, and Luseland.

JAPANESE BEETLE.—Trapping and scouting activities were continued in southern Ontario, and between early July and mid September a total of 733 beetles were collected as follows: Fort Erie, 8; Windsor, 92; Port Burwell, 230; and Hamilton, 403.

JUNE BEETLES.—In British Columbia, large numbers of *Polyphylla perversa* Csy. emerged from a local garden area near Lavington. No damage was reported in either Alberta or Saskatchewan, but in Manitoba reports of damage to potatoes, received from the Brandon, Alexander, Souris, and Virden districts, indicated increased populations of larvae. In Ontario, the flight of adults of *Phyllophaga* spp. was the largest on record and extended across the southern part of the Province from Lake Huron to Glengarry County. Major flights extended from Golden Lake to Renfrew and from Perth to Ottawa. Defoliation of deciduous trees and shrubs was severe, but most of these hosts put out new leaves later in the season. It was expected that in 1957 second-year white grubs would cause severe losses to many agricultural crops in the area affected. No severe damage was reported from either Quebec or the Atlantic provinces, although strawberries were moderately damaged in the latter area. In Nova Scotia considerable damage was done to various crops in the Debert-Masstown area.

MANTIDS.—In southwestern Ontario, the Chinese mantis, *Tenodera aridifolia sinensis* Sauss., was found for the first time in the Province near Harrow in 1955, and in 1956 several specimens were taken in the area. The European mantis, *Mantis religiosa* L., increased in numbers in the Chatham area and was taken for the first time in the Harrow area.

SAP-FEEDING BEETLES.—An outbreak of a sap-feeding beetle, *Glischrochilus fasciatus* (Oliv.), occurred in south-central and southwestern Ontario in 1956. Although generally considered a secondary problem, the insect was present in raspberries before and after picking, in corn that was injured or in which the husk was loose at the tip, and in cracks in tomatoes and other fruit and vegetables.

WIREWORMS.—In British Columbia, *Agriotes obscurus* (L.) caused considerable damage to corn at Agassiz and *A. sparsus* Lec. continued to damage potatoes near Ladner. An undetermined species damaged asparagus near Lavington. Some damage occurs in various crops every year throughout the central interior of the Province.

Wireworm damage to crops in southern Alberta was very light, probably associated with dry spring weather.

In Saskatchewan, wireworm damage occurred in 55 per cent of 237 cereal crop fields examined in a systematic survey. More than 10 per cent thinning was noted in seven per cent of the fields examined, but thinning in excess of 50 per cent was not observed; the average per field was 2.8 per cent. Most of the moderate to moderately severe thinning was in the central, southern, and western agricultural regions. Damage to all crops in the northern and east-central regions was very light; no damage to flax or rye was observed. Most wireworm populations consisted mainly of *Ctenicera aeripennis destructor* (Brown) and *Hypolithus nocturnus* Esch. together. Populations of *Ctenicera aeripennis aeripennis* (Kby.) and *Limonius pectoralis* Lec. appeared to be smaller than during recent years.

In Manitoba, most wireworm damage was sufficiently light as to be concealed by abundant growth resulting from heavy rains. For the first time in the Province, the species *Limonius dubitans* Lec. was recorded; it destroyed several acres of wheat near Beresford.

In southwestern Ontario, the widespread use of protective measures restricted injury to a minimum, but in untreated crops wireworms were more injurious than in 1955. *Limonius agonus* (Say) damaged potatoes, corn, and flue-cured tobacco in lgin County. Flue-cured tobacco was also damaged by *Aeolus mellillus* (Say) in Elgin and Norfolk counties. The wheat wireworm, *Agriotes mancus* (Say), severely thinned a field of soybeans in late July near Wallaceburg. This was the first observed damage to this crop in this area. Some damage to carrots was also reported.

In Quebec, wireworms damaged several crops, notably cereals and potatoes, in the Eastern Townships. *Dalopius* sp., *A. mancus, Hypolithus abbreviatus* (Say), and possibly *Althous* spp. were injurious to potatoes and turnips in muck soil areas about Ste. Clothilde.

In the Atlantic provinces a severe local infestation of *Melanotus* sp. occurred in timothy near Scotchtown, N.B. In Nova Scotia, *A. mancus* in the Annapolis Valley, *A. sputator* (L.) in the Sydney, Digby, and Weymouth areas, *A. obscurus* (L.) in the Halifax and Lunenburg areas, and *A. lineatus* (L.) in the Yarmouth area apparently occurred in normal numbers. *Oestodes tenuicollis* (Rand.) was found in Hants County; it is now known from Kings and Hants counties. *A. mellillus* was collected near Bridgetown; it is now known to occur in

Annapolis and Lunenburg counties. A European species, probably *Melanotus rufipes* (Hbst.), was found at Halifax in the roots of nursery stock from Holland. In Prince Edward Island, appreciable wireworm damage to potatoes was recorded for the first time, being found in a field near O'Leary. No unusual damage was recorded in Newfoundland.

FIELD CROP INSECTS

APHIDS.— No serious aphid infestations on field crops were reported in British Columbia, although moderate numbers of the pea aphid occurred on alfalfa in the Kamloops area.

In the Prairie Provinces, in contrast to conditions in 1955, aphids were of no importance on cereal crops. *Acyrthosiphon pisum* (Harr.) was present only in small numbers on alfalfa.

In Saskatchewan, *R. maidis*, which in 1955 occurred in the most severe outbreak ever experienced in the Province, was not collected on barley or other cereals, but light infestations were found in September on corn in several gardens in the central and north-central agricultural areas of Saskatchewan. Very light infestations of *M. granarium* were found on volunteer grain in a few fields in the Saskatoon and Ridgedale districts. *Toxoptera graminum* (Rond.) was not noted. Rape was lightly damaged locally at Central Butte by *Rhopalosiphum* sp. (probably *pseudobrassicae* (Davis)). and a light infestation of *Brevicoryne brassicae* (L.) occurred in a plot of late rape at Saskatoon. *Brachycolus tritici* Gill. was found on Lee wheat near Regina and occurred in the usual numbers on intermediate and crested wheat grass in laboratory plots at Saskatoon.

In eastern Manitoba, small numbers of *R. maidis* occurred in barley, but natural control agents prevented any build-up. At the University of Manitoba a clover aphid, *Myzocallidium riehmi* Borner, appeared for the first time in the Province; it fed on seedling sweet clover, causing the leaves to turn yellow.

In Ontario, too, aphids were less numerous on grain than in 1955. Only small to moderate numbers were found in most cereal crops, but a few fields of oats and barley suffered severe local damage, notably in southwestern areas. Only small numbers of *M. persicae* occurred on tobacco, but *R. maidis* was unusually abundant on corn, every plant in some areas being infested. In southwestern areas some large populations of the pea aphid developed on alfalfa.

In Quebec, light infestations of *R. maidis* occurred on barley in the Chateauguay Valley and at Lennoxville, but in general aphid populations were small.

In New Brunswick, in contrast with 1955, aphids were present on grain only in small numbers. However, *R. maidis* developed on corn in the largest numbers in nine years. Infestation of tassels on early corn amounted to 48.6 per cent and on late corn 15 to 40 per cent. In Nova Scotia, *R. maidis* was generally distributed on grain, but only in light infestations. In Prince Edward Island, *M. granarium* appeared generally on grain in mid August and became abundant in some fields, but the infestation was too late to cause much damage.

BILLBUGS.—In Ontario, a few fields of corn in Elgin, Waterloo, and Durham counties were severely damaged by *Calendra* sp., which rarely occurs in destructive numbers.

CLOVER-INFESTING WEEVILS.—At Prince George, B.C., the lesser clover leaf weevil was sufficiently abundant on alsike clover to cause some concern. In the Prairie Provinces, the sweetclover weevil damaged second-year stands of sweet clover in the Peace River area of Alberta, seedling stands in northeastern agricultural areas of Saskatchewan, and, although it was abundant in Manitoba, losses were overcome by good growing conditions. Counts made in Manitoba in August revealed the largest adult population in 11 years of observation. Minor damage occurred in seedling stands in Ontario and Quebec. The alfalfa weevil has become established throughout that part of southern Alberta bounded by the 49th parallel on the south and by the St. Mary, Oldman, anl South Saskatchewan rivers on the north. In Saskatchewan, the infested area extended north from the International Boundary about 100 miles, and from the Alberta border to within 65 miles of the Manitoba border. Infestations had not approached economic levels, although the percentage of fields infested and the degree of infestation appeared to be greater than in 1955. In Alberta, larvae of the clover leaf weevil damaged white dutch clover in a greenhouse at Lethbridge. The clover had been dug during the winter and transferred to the greenhouse. This was apparently the first time the insect had been taken in Alberta. *Sitona scissifrons* Say was again observed in many alfalfa fields in northeastern agricultural areas of Saskatchewan; no appreciable damage was recorded in this area, but an infestation caused severe damage to seedling alfalfa in field plots at Saskatoon. In Quebec, the clover root borer, *Hylastinus obscurus* (Marsh.), and a clover root weevil, *Sitona* sp., were observed in forage crops at Ste. Anne de la Pocatiere, but they did not cause any severe damage.

CORN EARWORM.—Garden infestations were reported from Okanagan Landing and Keremeos, B.C. The insect was not reported in either Alberta or Saskatchewan, and occurred in very small numbers in Manitoba. In Ontario it caused some concern to growers of late canning corn, some fields being almost 100 per cent infested, and it fed occasionally on tomato fruits. At St. Jean, Que., 1.3 per cent of corn ears were infested, but damage generally was not severe. In New Brunswick, damage to early corn ranged from 30 to 50 per cent and late corn was severely infested; most of the latter, however, failed to mature because of the weather. In Nova Scotia, only mid-season varieties were appreciably attacked and in Prince Edward Island and Newfoundland damage was light.

EUROPEAN CORN BORER.—In Saskatchewan, a survey was made of the southwest corner of the Province, extending 84 miles westward from Manitoba and 54 miles northward from the International Boundary. As in 1955, 100 per cent of the corn plots were infested, but the percentage of plants infested (1 to 65 per cent) and the number of larvae per plant were considerably lower. In Manitoba, after the heaviest infestation on record, in 1955, the borer occurred in extremely small numbers. Only an occasional larva was found on sweet corn in the Brandon area and one egg mass per 100 plants was found at Winnipeg and Morden. There was no damage in field corn. In southwestern Ontario, although the moth flight was one of the heaviest on record, a fall survey revealed 101 larvae per 100 plants, as compared with 173 larvae per 100 plants in 1955. Infestation of late corn was lower also in south-central and eastern Ontario, but some early corn was heavily infested. Surveys in southwestern Quebec showed that 25 per cent of the corn plants were infested with an average of 84 borers per 100 plants. The percentage of plants infested varied from 10 to 44 and the number of borers per 100 plants from 22 to 169. The average population in the plants was almost three times that of 1955, although the stalk infestation was lower by 50 per cent. An average of 7 per cent of the ears harvested were damaged—somewhat above normal. In New Brunswick, damage was light, but in Nova Scotia it was moderate to severe where no control measures were employed.

FLEA BEETLES.—Damage in the Prairie Provinces was at a generally low level, although light to moderate damage occurred in some fields of rape in the Brandon, Winnipeg, and Morden-Winkler areas.

LEGUME-POLLINATING INSECTS.—In Alberta, the population of *Megachile perihirta* Ckll. dropped for the second successive year and was only half of that recorded in 1954. Bumble bee populations were also at a low ebb, probably as a result of scarcity of mice nests. In northeastern agricultural areas of Saskatchewan queens of *Bombus terricola* Kby., *B. ternarius* Say, and *B. borealis* Kby. were fairly abundant in flowering crops in late spring and early summer. However, probably because of unfavourable weather conditions in early summer, workers did not appear in appreciable numbers until the first week of August, thereby greatly diminishing their value as pollinators. In Manitoba, the leaf-cutter bee population was very low in the Wanless area. Late emergence and nesting resulted in their doing little alfalfa pollination. The population of *B. terricola* was about 0.75 per square yard on alfalfa.

PLANT BUGS.—*Liocoris* (=*Lygus)* spp. were not important in Alberta. In Saskatchewan, species of this genus, chiefly *L. unctuosus* Kelton and *L. borealis* Kelton, were present in economic numbers in every alfalfa field examined in the northeastern agricultural area of the Province and in lesser numbers in red clover. At Wanless, Man., *L. lineolaris* (Beauv.) was not numerous enough on alfalfa to warrant control measures and reports from various areas of Eastern Canada indicated below normal populations. Near Northside, Sask., *Adelphocoris lineolatus* (Goeze) caused serious damage to alfalfa; it was generally present on this crop in the White Fox district, usually in small numbers, but causing some severe local damage. It occurred also on red clover in this area. The pest appeared to be increasing and spreading westward. In southeastern Manitoba this species was present on alfalfa in moderate infestations, but lush plant growth obscured damage. Populations on alfalfa and birdsfoot trefoil were above average in the Ottawa Valley, Ont. *Adelphocoris rapidus* (Say) occurred on alfalfa in small numbers in Saskatchewan and average numbers in Manitoba. *Plagiognathus* sp. occurred in normal numbers in northeastern agricultural areas of Saskatchewan and *P. chrysanthemi* (Wolff) was abundant on alfalfa and birdsfoot trefoil in the Ottawa Valley, Ont., apparently causing some bud blasting of the latter host.

SPITTLEBUGS.—An undetermined species was numerous in several pastures and meadows in the Cariboo, B.C., area and was particularly abundant on ox-eye daisy near Dragon Lake, B.C. The meadow spittlebug emerged late in southwestern Ontario and the first crop of hay was harvested before any build-up in numbers. In the Ottawa Valley, Ont., this species was more numerous than usual on alfalfa and birdsfoot trefoil, but did not cause much damage. Normal abundance was reported also from St. Anne de la Pocatiere, Que.

SUGAR-BEET INSECTS.—In Alberta, a sugar-beet root maggot, *Eurycephalomyia myopaeformis* (Roed.), caused serious damage to beets in the light sandy soil area at Taber and Cranford, but injury was lighter than in 1955. Approximately 3,000 acres of beets were treated with chemical seed dressing. In Manitoba, this root maggot caused damage at Steinbach in 1953 and at Altona in 1955 and 1956. In 1956, fields in a two-township area west and southwest of Altona were infested, but good growing conditions prevented serious losses. The insect is apparently established in the area.

The sugar-beet root aphid, *Pemphigus betae* Doane (=*P. balsamiferae* Williams), was present in most of southern Alberta. Populations were larger than in 1955. Reports were received from householders of the sugar-beet root aphid on lettuce, swiss chard, spinach, and beets. In a few sugar-beet fields in the Turin, Alta., area, adults of *Hypolithus nocturnus* Esch. were found clustered around open wounds on the tap roots of many of the plants, but they were considered merely secondary pests. The spinach carrion beetle also caused little

damage to this crop. In Ontario, sugar beets were relatively free of insect pests. Cutworms were reported, but damage was very slight. A few of the pale-striped flea beetle were found in one field.

SUNFLOWER INSECTS.—In Manitoba, the sunflower moth was very rare in 1956. There was an increase in the population of the banded sunflower moth, seed damage increasing from 1.7 per cent in 1955 to 2.6 per cent in 1956. *Chelonus* sp. near *shoshoneanorum* Vier. and *Glypta* sp. remained the important parasites of *Phalonia hospes* Wlshm. No cutworm damage was noted. No specimens of the painted-lady were seen. Numbers of the sunflower beetle were reduced from those of 1955 and no sigificant damage was noted. *Lebia atriventris* Say, a predator of *Zygogramma exclamationis* (F.) was less abundant than in 1955. The sunflower maggot was more abundant. Of the stalks examined in the main sunflower-growing area, 95.4 per cent were infested. This is an increase from 87.9 per cent in 1955 and 66.8 per cent in 1954. *Oedicarena diffusa* Snow. was present in its usual small numbers, as was *Euarestoides finalis* (Loew). The ragweed plant bug, *Liocoris* spp., and leafhoppers were less abundant than in recent years. A weevil, species undetermined, was taken in considerable numbers on sunflowers in Manitoba for the first time. It was responsible, at least in part, for what is commonly known as sunflower head drop.

THRIPS.—*Haplothrips niger* (Osb.) was again common in small numbers in red clover fields in northeastern agricultural Saskatchewan, causing little damage. In Manitoba, several reports of thrips infesting barley in the boot stage were received from the Brandon area and other sections of the Province, but damage was not evident. In Ontario, *Anaphothrips obscurus* (Müll.) was common in oat and corn fields in the Ottawa area, several fields being moderately damaged at Kemptville, North Gower, Manotick, Almonte, Packenham, Carp, Richmond, and Bell's Corners. Most of the injury was on the lower leaves of the plants. Barley and timothy were also attacked. In Quebec, this species and *Limothrips cerealium* Hal., which were fairly abundant on barley heads in the Ste. Anne de la Pocatiere area in 1955, were scarce during the season.

WHEAT MIDGE.—In British Columbia, no reports of damage by the wheat midge were received, despite the relatively severe damage suffered in several districts in 1955. In eastern Manitoba this midge was again present in considerable numbers. It caused considerable damage in wheat breeding plots at the University of Manitoba, with losses described as 10 to 30 per cent.

WHEAT STEM SAWFLY.—In Alberta, parasitism of the wheat stem sawfly by *Bracon cephi* Gahan appeared to have increased in the Lethbridge area. Sawfly populations have been increasing recently in the Foremost, New Dayton, and Hilda-Schuler areas of the Province.

In Saskatchewan this insect caused less damage than at any other time since surveys were started and no inquiries were received from farmers during the season. In Manitoba, also, infestation was very light. In southwestern Ontario, the European wheat stem sawfly, as usual, was present in small numbers. The only report of injury was received from west of Tilbury, where 8 to 10 per cent damage was estimated.

VEGETABLE INSECTS

ALFALFA LOOPER.—In British Columbia, the alfalfa looper was abundant in young lettuce crops at Cloverdale in June.

APHIDS.—On Vancouver Island, B.C., and in the lower Fraser Valley, *Macrosiphum solanifolii* (Ashm.) and *Myzus persicae* (Sulz.) were absent on potatoes until mid August, but by harvest had developed some severe infestations. This was generally true also of *Brevicoryne brassicae* (L.) on cabbage. Aphids on potatoes were not a serious problem in the interior. Most other aphid pests of field and garden crops were less numerous than usual. A notable infestation of winged aphids on onions at Kelowna, B.C., comprised the following species: *Hyalopterus pruni* (Geof.) (=*H. arundinis* (F.)), *Macrosiphum granarium* (Kby.), *Myzus persicae*, *Aphis fabae* Scop., *Aphis pomi* DeG., and *Cavariella aegopodii* (Scop.). Damage to the onions was negligible. No important infestations on vegetables were reported in Alberta. In Saskatchewan, the cabbage aphid occurred in large numbers on cruciferous hosts in truck gardens at Saskatoon and the sugar-beet root aphid was present on beets. In Manitoba no very injurious populations of aphids were reported. In southwestern Ontario widespread but light infestations of the pea aphid and the cabbage aphid were reported. At Merivale, Ont., near Ottawa, the cabbage aphid was extremely scarce. In Quebec, a few severe infestations of the pea aphid developed at Marieville and St. Cesaire. In the Richelieu Valley infestation was light and in the St. Jean area very light. Aphids on potatoes were not a problem in the Province. In New Brunswick, population build-up on potatoes was slow and reached only about one-third that of 1955. A conspicuous phenomenon was recorded in the species *Aulacorthum solani* (Ktlb.). In 1956, 30 per cent produced wings and over 30 per cent of these produced wings on one side of the body only, the majority being on the left. In Nova Scotia, aphids were less numerous than in 1955 on potatoes. In Prince Edward Island, *M. solanifolii* was present in large numbers in many potato fields; other species were very scarce. No infestations were reported in Newfoundland.

ASPARAGUS BEETLES.—In Ontario, the spotted asparagus beetle was generally scarce. The asparagus beetle developed late in southwestern areas and caused light general damage. It was scarce to absent in eastern Ontario.

CATERPILLARS ON CABBAGE.—In the interior of British Columbia, the imported cabbageworm occurred in light infestations in the Okanagan and at Cranbrook. It was abundant and injurious in the Prairie Provinces. In Ontario, populations in the southwestern area were greatly reduced from those of 1955, but damage to late cabbage was extensive. In eastern Ontario, infestation was generally very light, being almost nil on early cabbage; cruciferous hosts were not seriously damaged until September. In the Kamouraska, Que., district, infestation of cabbage and cauliflower was moderate to severe. In New Brunswick and Nova Scotia infestation was normal, but later than usual. Light infestation was reported in Prince Edward Island and Newfoundland.

The diamondback moth widely attacked cole crops in British Columbia, causing 100 per cent loss of cauliflower in a field at Salmon Arm. In Alberta it damaged mustard, cabbage, and rutabaga. No damage was reported in Saskatchewan or Manitoba. In southwestern Ontario it appeared unusually early and was found on early cabbage for the first time. In the Ottawa, Ont., area, populations were the smallest in three years. No serious infestations were reported in the Atlantic provinces.

The cabbage looper was not reported in Western Canada and was generally at a low ebb in Eastern Canada, excepting the Burlington and Kemptville, Ont., areas, where numbers were moderate; New Brunswick, where normal numbers developed late in the season; and Newfoundland, where a slight increase occurred.

CARROT RUST FLY.—Infestation of carrots in British Columbia was generally light and appreciable damage occurred only in the few crops that were harvested late. In Ontario, populations remained small, as in 1955, and the insect had failed to become re-established in significant numbers in the Holland Marsh, where it had been subjected to prolonged flooding in October, 1954. In Quebec, early-season development was retarded, but late crop carrots were commonly damaged. In Nova Scotia appreciable damage was restricted to small gardens. In New Brunswick damage ranged from light in the Fredericton area to medium to severe in the Maugerville-Sheffield area. Infestation was generally light in Prince Edward Island and Newfoundland with some severe damage in backyard gardens.

CELERY LEAF TIER.—Control measures were employed to protect parsley against this pest in the Chatham, Ont., area.

COLORADO POTATO BEETLE.—In British Columbia, light infestations were general throughout the Kootenay area. In Alberta and Saskatchewan the insect was generally of little importance, except in small gardens. In Manitoba survival of over-wintering adults was the highest in several years. Population build-up was rapid and damage severe in neglected crops. No beetles were observed in the Pas-Wanless area. Increased abundance was reported also in Ontario and Quebec, tomatoes being attacked to an unusual degree in southwestern Ontario. In the Atlantic provinces, excepting Newfoundland, normal to above-normal numbers were reported.

CORN ROOT WEBWORM.—In Ontario, several growers in the northeastern end of the Holland Marsh lost a considerable acreage of early-planted carrots because of damage caused apparently by this insect. At least three growers lost their early crops and about 10 per cent of the mid-season carrots were damaged, but late-planted carrots were not infested.

CUCUMBER BEETLES.—The striped cucumber beetle was generally abundant in Eastern Canada excepting Nova Scotia, where it was less numerous than in 1955. No reports were received from Newfoundland. Small numbers of the spotted cucumber beetle caused little damage in southwestern Ontario.

FLEA BEETLES.—The potato flea beetle occurred at Brandon and Dauphin, Man., in the heaviest infestations in several years. Populations were below average in many areas of Ontario, Quebec, and New Brunswick, but normal to above normal in Nova Scotia and Prince Edward Island. Little injury occurred in Newfoundland. *Phyllotreta* spp. were not numerous in the Winnipeg and Brandon, Man., areas, but were more numerous than usual at Dauphin. *P. striolata* (F.) caused moderate, general damage to radish and turnips in Ontario and was abundant on cabbage and cauliflower in New Brunswick. *Phyllotreta* sp. caused widespread, severe damage to crucifers in the Ottawa Valley, destroying many thousands of cabbage and turnip seedlings. Appreciable numbers were noted also in southern Quebec. In British Columbia, after several years of light infestation in coastal areas, *Epitrix tuberis* Gent. was reported by several farmers. In the interior of the Province damage was severe, as usual, in the Okanagan and Thompson valleys. Second-generation beetles fed on couch grass, alfalfa, Chinese cabbage, lettuce, carrot foliage, and other hosts.

HORNWORMS.—The tomato hornworm and the tobacco hornworm caused little damage in southwestern Ontario. The former was fairly numerous in southern areas of eastern Ontario.

LEAFHOPPERS.—The potato leafhopper was much less numerous than in 1955 in Manitoba and most of Eastern Canada; a light infestation occurred on apples at Morden, Man. The six-spotted leafhopper, too, occurred in smaller numbers than usual in most areas; in Manitoba

the incidence of aster yellows on lettuce and carrots was very low, but in Nova Scotia the disease was much more evident than usual in the New Glasgow area.

LEAF MINERS.—In British Columbia, unusually heavy infestations of the spinach leaf miner occurred on spinach in the Okanagan Valley from Penticton to Armstrong. No damage was reported in Manitoba. In southwestern Ontario spotty, light infestations occurred on beets and spinach. Also, in this area an undetermined species was numerous on cabbage and beans.

MAGGOTS IN ONIONS.—In the interior of British Columbia the onion maggot caused severe damage in untreated plantings, but nearly all commercial growers used insecticides. In Saskatchewan damage was less than in 1955 and in Manitoba it ranged from light to nil. In most of Eastern Canada, too, infestation was below average, although as widespread as usual. The muckland areas of southern Quebec were an exception, damage being moderate to severe where no insecticides were used. In the interior of British Columbia, *Paragopsis strigatus* (Fall.) caused some severe damage to onions.

MEXICAN BEAN BEETLE.—Although abundant on beans in the late summer of 1955, this insect was extremely scarce in suburban gardens near Niagara Falls; light foliage injury was noted on dwarf beans toward the end of the season.

PEA MOTH. — In British Columbia, the pea moth severely attacked garden peas at Saanichton, infesting more than half of the pods in one crop. This appears to be the first record of heavy infestation of this pest on Vancouver Island. It was reported from gardens in Vancouver and White Rock on the mainland. In Nova Scotia it was more numerous than for three years in the Truro area and in Prince Edward Island it caused moderate to severe damage in gardens, but minor damage in commercial stands.

PEA WEEVIL.—Appreciable infestations were reported only in the Fredericton, N.B., area, where they were severe in small gardens.

PLANT BUGS.—Populations of *Orthops* (=*Lygus) scutellatus* Uhl. were very large in carrot seed crops at Grand Forks, B.C. *Chlamydatus associatus* (Uhl.) damaged the terminal growth on cucumbers near Ottawa, Ont., the first record of injury of this nature in the area. *Liocoris* (=*Lygus lineolaris* (Beauv.) caused considerable damage in the marginal areas of potato fields in Nova Scotia.

POTATO STEM BORER.—This insect caused considerable damage to sweet corn, rhubarb, potatoes, and tomatoes in southern Quebec and in Nova Scotia.

ROOT MAGGOTS IN CRUCIFERS.—The cabbage maggot attacked cruciferous crops in considerable numbers in coastal and interior areas of British Columbia. In Alberta first-generation mortality was high and damage very light. In southwestern Ontario, infestation of turnips was below average and not serious. In the Ottawa Valley damage to early cabbage and cauliflower was the lightest in several years, but late-season damage to turnips destroyed up to ten per cent of the roots. In southern Quebec infestation was generally high. In New Brunswick, cool weather greatly restricted oviposition and damage was below average. Near-normal damage was reported in Nova Scotia and generally light to moderate damage in Prince Edward Island and Newfoundland. In Saskatchewan *Hylemya floralis* (Fall.) caused only slightly less damage than in 1955, when in truck farms 20 to 30 per cent of untreated cabbage and cauliflower were killed and 60 to 70 per cent of untreated rutabagas damaged. At Brandon, Man., this species was slightly more numerous than in 1955, but populations of *H. planipalpis* (Stein.) were small.

SEED-CORN MAGGOT.—At Cloverdale, B.C., this maggot accounted for about 25 per cent of the maggot population on rutabagas in July. No damage was reported in the Prairie Provinces. In southwestern Ontario, infestations in peas, beans, cucumbers, melons, spinach, and corn were generally light, although it was necessary to re-seed a few fields of navy beans and soybeans. In the Ottawa Valley damage was general, losses amounting to about 25 per cent in snap beans seeded after June 1. In Quebec, too, the insect was generally injurious. Reduced populations were noted in the Atlantic provinces, but some severe damage occurred on beans.

SLUGS.—Slugs continued to be a nuisance in gardens in many areas of British Columbia. In Manitoba increased distribution and continued abundance in an increasing area were noted in the Winnipeg area. In Ontario slugs were rated to be by far the most important pest in many home gardens and damage was the greatest in several years. Such field crops as turnips, potatoes, and tomatoes were also extensively attacked. In Quebec and the Atlantic provinces, too, extensive damage to garden crops was reported. The general abundance was apparently associated with the wet season.

SPIDER MITES.—In British Columbia spider mites, probably, *Tetranychus bimaculatus* Harvey, caused damage to potato vines at several localities in the lower Fraser Valley. This was the first time such damage was observed in the area. This species was considered to be responsible for damage to beans in several gardens in Kamloops. *Petrobia latens* (Müll.) again caused some concern among onion growers in the Kelowna district.

SQUASH BUG.—This insect was somewhat more abundant than in 1955 on pumpkin and squash in southwestern Ontario, and on field pumpkins in the Frankford and Campbellford areas of eastern Ontario.

SQUASH VINE BORER.—In southwestern Ontario this insect appeared about two weeks later than usual. Extensive damage was, as usual, confined mainly to small gardens.

THRIPS.—Light to moderate infestations of the onion thrips developed in the Erieau, Ont., onion-growing area.

FRUIT INSECTS

APHIDS.—*Aphis pomi* DeG. was one of the most difficult pests to control on apple in British Columbia. In Essex County, Ont., infestation of apple was generally severe and prolonged, but elsewhere in the Province injury was generally light. In Quebec and the Atlantic provinces this species caused little damage, local infestations being controlled by natural means. *Anuraphis roseus* Baker continued at a low ebb in British Columbia, southern Quebec, and New Brunswick, but a few heavy infestations occurred in Norfolk and Essex counties, Ont. *Eriosoma lanigerum* (Hausm.) was at the lowest ebb in several years in British Columbia and of little importance in Eastern Canada. *Myzus cerasi* (F.) continued to be the most important pest of cherries in British Columbia. In Ontario it was abundant in Essex County, but rather scarce elsewhere. *Hyalopterus pruni* (Geof.) was troublesome in British Columbia and Essex County, Ont. *Myzus persicae* (Sulz.) was a minor pest on fruit in most areas. *Myzus ascalonicus* Doncast. did not recur on strawberries in British Columbia. In New Brunswick a survey of aphids on strawberry revealed *Capitophorus minor* (Forbes) anl *C. fragaefolii* (Ckll.), in trace numbers in most plantations in central areas. *Myzus porosus* Sand. was present in local infestations in the Belleisle area. In southern Manitoba *Capitophorus ribis* (L.) heavily infested currants.

APPLE (AND BLUEBERRY) MAGGOT.—In Manitoba the population of this insect on apple was small. In Ontario, emergence was two weeks later than usual and large populations caused the greatest damage in several years in most areas. In Quebec the insect was not a serious pest. In New Brunswick a marked increase in incidence and damage caused considerable concern to growers. In Nova Scotia a general increase was indicated and in Prince Edward Island numbers were normal. Populations on blueberry were not large in New Brunswick, excepting a few untreated barrens, and were below normal in Prince Edward Island.

APPLE MEALYBUG.—This insect occurred generally as a very minor pest of apple in Nova Scotia and New Brunswick.

APPLE SEED CHALCID.—Infestation of this chalcid was very high on apple at Morden, Man.

APPLE SUCKER.—Populations of this pest were the smallest in several years in Nova Scotia.

BLACK-HEADED FIREWORM.—This insect was fairly abundant in cranberry bogs on Lulu Island, B.C.

BLUEBERRY SAWFLY.—A considerable increase in numbers occurred in Charlotte County, N.B.

CHERRY FRUIT FLIES.—*Rhagoletis cingulata* (Loew) continued to be a major pest on unsprayed sweet and sour cherries on southern Vancouver Island, B.C. Unsprayed orchards were 55 to 100 per cent infested. *Rhagoletis fausta* (O.S.) appeared in orchards from late July to September, but did not constitute a problem.

CHERRY FRUITWORM.—Moderate injury occurred in several cherry orchards at Vernon, B.C., and infestation in the east Kelowna area was greater than in 1955. Small numbers were reported in coastal areas.

CICADAS.—Cicadas were unusually numerous in British Columbia, damaging fruit trees from Kelowna to Salmon Arm; they were particularly numerous in the Kootenay and Okanagan valleys.

CODLING MOTH.—Losses were considerable in British Columbia, where the insect was more numerous than in several previous years. In Ontario control was easier than usual because of the cool, wet weather and damage was light. In southern Quebec the insect persisted as a major pest, although it was somewhat less numerous than in 1955. In New Brunswick populations remained generally small. In Nova Scotia a slight increase occurred in the Annapolis Valley and in Prince Edward Island minor damage was noted, after several years of almost complete absence.

CRANBERRY FRUITWORM.—For the first time in many years, populations of this fruitworm decreased markedly in New Brunswick and damage was light. In Prince Edward Island, too, little damage occurred.

CURCULIONIDS.—In Manitoba, infestation by the plum curculio was severe in the Morden area. In Ontario this pest was less troublesome than usual on stone fruits in the Niagara Peninsula, but elsewhere in the Province it caused the greatest damage in several years on both peach and apple; in eastern Ontario injury to apple, cherry, plum, and pear was the most severe ever observed, due largely to favourable temperatures in early June. In Quebec populations were large and in the Atlantic provinces about normal. *Anthonomus signatus* Say was generally distributed in strawberry plantings from Manitoba eastward, but damage was of minor importance. In British Columbia, strawberry plantings on untreated soil on the Saanich Peninsula were more heavily infested with both *Brachyrhinus sulcatus* (F.) and *B. ovatus* (L.) than in 1954 or 1955. Loganberry plantings adjacent to strawberries planted on treated soil

were heavily infested with *B. sulcatus* adults. Larvae of this species were also common around the loganberry roots. At Smithers, B.C., large numbers of adults of *B. ovatus* came through threshing machines with the grain at harvest. At Winnipeg, Man., a heavy infestation was reported. In southeastern Ontario adults commonly invaded dwellings, but in Essex County the insect was less numerous than in 1955. Dwellings were invaded also in Kamouraska County, Que., and in New Brunswick and Nova Scotia. Field injury was generally light from Quebec eastward to Nova Scotia. *B. sulcatus* was usually present along with *B. ovatus*. Also present in damaging numbers were two undetermined species of the genus *Nemocestes*. These three species have been present for many years but have only recently become economic pests. *Brachyrhinus singularis* (L.) fed extensively on raspberry on Vancouver Island.

CURRANT FRUIT FLY.—This insect caused some damage in Alberta. In Saskatchewan populations continued to decline for the third successive year, and in Manitoba general infestation of currant and one report of damage to gooseberry were reported.

EYE-SPOTTED BUD MOTH.—In British Columbia this fruit pest was more abundant than usual on apple and pear, up to five per cent of the fruit of the former being injured. In Eastern Canada infestation continued to be light except in a few orchards, notably in the Rougemont and St. Anne de la Pocatiere areas of Quebec. In Nova Scotia the endoparasite *Agathis laticinctus* (Cress.) accounted for about 40 per cent reduction in hibernating larvae.

FRUIT TREE BORERS.—The roundheaded apple tree borer was comparatively scarce in Eastern Canada. The peach twig borer was of minor importance in British Columbia and Ontario, excepting one young orchard in Norfolk County, Ont., where infestation was heavy. The peach tree borer was restricted mainly to neglected orchards in peach-growing areas. The lesser peach tree borer caused considerable damage to peach in Essex County, Ont., and the currant borer was numerous at Vernon and Wyndell, B.C., and in light infestation at Morden, Man.

GRAPE BERRY MOTH.—In Ontario injury in the Niagara area was considerably less than in 1955 and no serious infestations were reported elsewhere in the Province.

GREEN FRUITWORMS.—The fall cankerworm was scarce at Morden, Man., and not a serious fruit pest elsewhere except in Nova Scotia, where an increase necessitated control measures in many orchards. *Grapholitha prunivora* (Walsh), *Hedia variegana* (Hbn.), *Lithophane* spp., and *Xylena* spp. were all comparatively scarce.

IMPORTED CURRANTWORM.—The lightest infestations in years were commonly reported from Manitoba to Newfoundland and the insect was not reported west of Manitoba.

LEAFHOPPERS. — In British Columbia, populations of *Macropsis fuscula* (Zett.) had been large on loganberries in the Lulu Island area since 1952. However, in November, 1955, a severe freeze destroyed all loganberry canes containing the leafhopper eggs and no infestations were found in commercial plantings in 1956. Wild blackberries growing in the area were less severely affected by the cold weather and small populations of leafhoppers survived on this host. This species is increasing in the Keating area of Vancouver Island, where it was first observed during 1955. Traps placed in loganberry and raspberry plantings in the lower Fraser Valley and on Vancouver Island revealed the following economic species: *Ribautiana tenerrima* (H.-S.), *Edwardsiana rosea* (L.); *E. prunicola* (Edw.), *Empoasca* sp., and *Erythroneura* sp. The first two were by far the most abundant and most troublesome. In Nova Scotia *Typhlocyba pomaria* McA. was less numerous than in 1955, but was present in moderate infestations. *Erythroneura* spp. continued to be scarce in commercial vineyards in Ontario. Undetermined leafhoppers damaged plum and prune in British Columbia and were numerous on apple at Rougemont, Que.

LEAF ROLLERS.—In the main fruit-growing areas of British Columbia *Archips argyrospila* (Wlkr.) was more abundant than for several years, and in southern Quebec it required control measures in many apple orchards. In Ontario and Quebec, *Argyrotaenia velutinana* (Wlkr.) was generally more abundant than in 1955 and severe injury by the second generation resulted in some apple orchards where control measures were inadequate. One very severe infestation occurred on pear in the Niagara Peninsula, injuring approximately 20 per cent of the fruit. In Nova Scotia *Argyrotaenia mariana* (Fern.) was more widespread than in 1955, causing trace amounts of damage in more orchards than usual, but most of the orchards that had had moderately heavy infestations in recent years showed some reduction in numbers. In the lower Fraser Valley, B.C., *Archips rosaceana* (Harr.) was not a problem, even in filbert orchards that had been heavily infested in previous seasons. In Ontario small numbers of *Archips semiferana* (Wlkr.) were taken in one orchard in Norfolk County after an apparent absence for several years. Also, in this county and in the Oakville-Bronte area, the strawberry leafroller occurred in light to moderate infestations. In British Columbia *Exartema olivaceanum* (Fern.) was again abundant on strawberry plantings in the Keating area.

MITES.—In British Columbia, the European red mite was as abundant and injurious as in 1955. In Ontario it was generally less abundant than usual on apple and peach except in Essex County, where populations built up to large numbers and produced the most overwintering eggs observed for several years. Large populations developed also in many areas of

southern Quebec, but in the Atlantic provinces the species was of economic importance in only a few orchards. In the St. John River Valley, N.B., it had almost disappeared after being a serious pest in 1955. In British Columbia *Tetranychus bimaculatus* Harvey was present on strawberry and raspberry in very large numbers in the lower Fraser Valley and in moderate numbers in the interior. In Ontario, only light infestations were noted on fruit trees in most areas, but in Essex County large populations developed in many apple and peach orchards. Moderate damage occurred in a few orchards in Quebec. In the major fruit-growing areas of British Columbia, winter damage by *Eriophyes pyri* (Pgst.) was widespread and severe. In Ontario a survey of nurseries in the Niagara Peninsula revealed 18 infestations in three counties. Scattered minor infestations were reported in Quebec, New Brunswick, and Nova Scotia, but in Prince Edward Island damage to pear was widespread and severe. Populations of *Bryobia praetiosa* Koch remained at a low ebb in British Columbia, and in Nova Scotia were smaller than in 1955, rarely requiring control measures. In the main fruit-growing areas of British Columbia, *Tetranychus pacificus* McG. and *Tetranychus mcdanieli* McG. were very troublesome on apples and pears, *Eotetranychus carpini* (Oudms.) remaining at low population levels, and *Vasates schlechtendali* (Nal.) became a major pest. In Saskatchewan mites caused light, general damage on raspberries, the first since 1952, and in the Grand Lake, N.B., area strawberries were heavily infested.

ORIENTAL FRUIT MOTH.—In British Columbia this insect was discovered in September in peaches imported by a Summerland cannery from Yakima, Washington, U.S.A. About 500 bushels of fruit were apparently infested by larvae in various instars. Measures were undertaken in an attempt to eradicate the pest and prevent it from becoming established in the Province. In Ontario the moth remained at a compartively low level of infestation. In Essex County it was considerably less abundant than in 1955. In the Niagara Peninsula late injury to Elberta peaches was somewhat heavier than usual in a few orchards. A survey of nurseries in this area revealed infestation in 16 separate blocks of peach stock and three of plum.

PEAR PSYLLA.—In British Columbia the pear psylla was a problem in some orchards, particularly from Summerland south to the International Boundary. In Ontario, as a result of unfavourable weather, the insect was much less abundant than in 1955.

PEAR SLUGS.—The pear slug was of minor importance generally in Canada, although some moderate damage to cherry was reported in Prince Edward Island. A survey of nurseries in the Niagara Peninsula, Ont., revealed many infestations on pear, cherry, quince, and plum. In British Columbia *Pristiphora californica* (Marl.) also was a minor pest.

PLANT BUGS.—The tarnished plant bug was of minor importance in fruit orchards in British Columbia, but commonly infested strawberry in southern Manitoba and caused serious, widespread injury to the fruit of peaches in the Niagara Peninsula, Ont. In Nova Scotia *Campylomma verbasci* (Meyer) was less numerous than in 1955, but it and *Criocoris saliens* (Reut.) caused some fruit injury. A few orchards continued to have light to moderate infestations of *Neolygus communis novascotiensis* Kgt. and one light infestation of *Lygidea mendax* Reut. was recorded.

RASPBERRY BUD MOTH.—In New Brunswick this insect was widely distributed in infestations comparable to those of 1955.

RASPBERRY CANE BORERS. — *Oberea* spp. were less numerous than usual in Essex County, Ont., but were very conspicuous in eastern Ontario and common in southern Quebec. In New Brunswich and Nova Scotia, populations were small and generally below average, although somewhat troublesome at Truro, N.S.

RASPBERRY CANE MAGGOT.—In coastal areas of British Columbia, this pest was present in most loganberry and raspberry plantings, an alarming increase in infestation being apparent on new canes.

RASPBERRY FRUITWORMS.—In the lower Fraser Valley, B.C., small numbers of larvae of *Byturus bakeri* Barber were found on raspberries entering packing plants, control measures having been neglected because of severe frost damage to the canes. *Byturus* sp. was only rarely reported in Saskatchewan and Manitoba.

RASPBERRY SAWFLY. — This insect was reported as a minor pest in coastal areas of British Columbia, at Moose Jaw and Saskatoon, Sask., and Morden, Man. In eastern Ontario it caused considerable defoliation of wild and cultivated raspberry.

RASPBERRY ROOT BORER.—In coastal areas of British Columbia this pest appeared to be on the increase, causing severe damage to commercial loganberry and raspberry plantings. In some plantings as many as five larvae per crown were found.

SCALE INSECTS.—In most fruit-growing areas of Canada the oystershell scale occurred only as a minor pest, although some increase was indicated in southern Quebec and a few concentrations occurred in Prince Edward Island. A survey of nurseries in the Niagara Peninsula revealed generally reduced populations, although some medium infestations were present on young fruit trees. In British Columbia some increase in *Aspidiotus perniciosus* Comst. was noted where the use of organic phosphates had been suspended. Elsewhere in Canada the species was not a problem. Eight infestations were found in a survey of nurseries in the Niagara Peninsula. *A. ostreaeformis* Curt. was of little importance in British Columbia and Ontario. In the Niagara Peninsula light to moderate infestations of *Lecanium corni* Bouché occurred in

several peach and plum orchards and in Essex County, Ont., a partial second generation appeared for the second successive season. In British Columbia *Pulvinaria* sp. was of minor importance, but *Lecanium* spp. were more abundant in the Okanagan Valley than for ten or more years. Infestations were most severe on peach and apricot, but moderate infestations were found in some prune and apple orchards where dormant oil sprays were omitted. In the Niagara Peninsula populations of *Pulvinaria amygdali* Ckll. declined to unimportant numbers in peach orchards and at Morden, Man., *Chionaspis furfura* (Fitch) occurred in light infestations on apple and pear.

TENT CATERPILLARS AND WEBWORMS. – In coastal areas of British Columbia *Malacosoma pluviale* (Dyar) was less abundant than in 1955, but warranted control measures in some orchards. Strawberry plants were also damaged. *Malacosoma* spp. were at a very low ebb in Saskatchewan and of very little importance to fruit growers in Eastern Canada. In Nova Scotia *Hyphantria cunea* (Drury) increased markedly, notably in the Annapolis Valley.

THRIPS.—In British Columbia "pansy spot" of apple, presumably caused by *Frankliniella occidentalis* Perg., increased somewhat, particularly in northern areas of the Okanagan Valley where the variety McIntosh was abundant. In New Brunswick *Frankliniella vaccinii* Morgan again showed increases on blueberry in Charlotte County and other parts of the Province. In Nova Scotia it remained at about the same level as in recent years and on Prince Edward Island it was fairly common in new burns.

YELLOW-NECKED CATERPILLAR.—In British Columbia it was necessary to apply special sprays in many orchards to control this pest. It was reported in small numbers in southern Quebec and Nova Scotia.

PARASITES AND PREDATORS OF ORCHARD PESTS.—In southern Ontario populations of *Trichogramma* spp., *Ascogaster* spp., coccinellids, and lacewings remained at a low level. In Nova Scotia predators of apple pests were present in about the same numbers as during the past few years, but showed the usual fluctuations in individual species. *Haplothrips faurei* Hood, *Campylomma verbasci* (Meyer) and *Criocoris saliens* (Reut.) declined in numbers, but there was an increase in *Hyaliodes harti* Kgt. and *Anystis agilis* Banks. *Anthocoris musculus* (Say) continued in normal numbers and there was little change in the high population level of phytoseiid predator mites that had persisted during the previous few years.

INSECTS AFFECTING GREENHOUSE AND ORNAMENTAL PLANTS

ANTS.—Ants were particularly numerous in lawns and flower gardens in Saskatchewan and Ontario.

APHIDS.—The balsam woolly aphid continued to be a serious pest in the Atlantic provinces. In Manitoba the boxelder aphid was less abundant than in 1955 at Brandon, but occurred in heavy infestations at Morden. At Chatham, Ont., *Lachnus salignus* (Gm.) severely infested weeping willow late in the season. A woolly aphid, *Eriosoma crataegi* (Oest.), infested hawthorns, *Crataegus* spp., in nurseries in the Niagara Peninsula.

BARK BEETLES.—In Ontario over 40 elm trees along the Niagara River and a few as far inland as Vineland and Grimsby were found to be infected with Dutch elm disease, apparently the result of a sudden influx of the bark beetle *Scolytus multistriatus* (Marsh.), a vector of the disease. Large populations of the beetle in Kent County were associated with a marked increase in the disease in the Chatham area. In the St. Georges, Nfld., district, several hundred over-mature white spruce were killed by *Dendroctonus picaperda* Hopk.

BIRCH SKELETONIZER.—In Edmonton, Alta., the most conspicuous damage to shade trees by a lepidopterous insect was that caused by the birch skeletonizer, which disfigured nearly all birches; what appeared to be the same species was present in weeping birch.

BULB FLIES.—In British Columbia the narcissus bulb fly was present in reduced numbers, apparently as a result of improved control measures. In Nova Scotia the lesser bulb fly severely damaged narcissus bulbs at Birch Grove, Cape Breton County.

CURCULIONIDS.—On Vancouver Island, B.C., *Brachyrhinus singularis* (L.) occurred in large numbers, feeding at night on iris in home gardens. The rose curculio was moderately injurious to roses in Saskatchewan and numerous at Brandon and Morden, Man. In Ontario *Apion longirostre* Oliv., first found in the Niagara Peninsula in 1954 on hollyhock, continued to decline in numbers. In Newfoundland a pine root weevil, *Hylobius pinicola* (Couper), damaged Scots and red pines at Colliers Ridge and on the Avalon Peninsula.

LEAF BEETLES.—In Alberta *Chrysomela scripta* F. was common on poplar and willow in shelter-belts. In the Niagara Peninsula, Ont., *Galerucella xanthomelaena* (Schr.), was somewhat less numerous on elm than in 1955, but hibernating adults were the cause of innumerable inquiries from householders. A heavy infestation was reported also from Iberville, Que. In survey work in the Niagara Peninsula, *Plagiodera versicolora* (Laich.) was found on willow as far west as Beamsville.

LEAFHOPPERS.—The Virginia-creeper leafhopper caused the usual severe damage to Virginia creeper in the Kamloops, Vernon, and Kelowna, B.C., districts and in southern Alberta. A report of damage was received also from Tugaske, Sask. Unidentified leafhoppers damaged Manchurian elm in Lethbridge, Alta., and caused a negligible amount of aster yellows in Saskatchewan.

LEAF MINERS.—The lilac leaf miner was normally abundant in Eastern Canada except in Prince Edward Island, where it was more injurious than in recent years. In Hastings County, Ont., *Baliosus ruber* (Web.) increased noticeably on basswood. In both Ontario and Quebec *Fenusa pusilla* (Lep.) was common on ornamental birch. In the Okanagan, Arrow Lakes, and Grand Forks, B.C., areas, *Phyllocnistis populiella* Cham. occurred on aspen.

MELIGETHES SP.—This small beetle infested flowers of sweet peas grown commercially at Abbotsford, Que. The presence of beetles inside the flowers after cutting and packing adversely affected sales.

MITES.—In British Columbia the cyclamen mite was common on British Sovereign strawberry foliage in the Keating area, but caused little damage. In greenhouses it was the major pest of African violets and cyclamen. At Vernon, an undetermined mite damaged ornamental cedar and juniper. In Alberta spider mites were common on many hosts, but in Saskatchewan and Manitoba ornamentals were not seriously attacked. In Manitoba eriophyid galls were rather common on maple, basswood, and Virginia creeper. In Essex County, Ont., *Tetranychus bimaculatus* Harvey was a problem in greenhouses and in southern Quebec it was much less numerous on ornamentals than in 1955.

PEAR-SLUG.—Near Lethbridge, Alta., cotoneaster and mountain ash were attacked and in Manitoba cotoneaster and plum were more heavily infested than usual.

PINE SHOOT MOTHS.—In Ontario the European pine shoot moth continued to be a serious pest on ornamentals and in Christmas tree plantings and nurseries. In Newfoundland populations showed some increase. In Prince Edward Island *Eucosma gloriola* Heinr. was less injurious to pine than in 1955.

PLANT BUGS.—The boxelder bug was reported from Lillooet and Vernon, B.C., and from southern areas of Ontario and Quebec, where it was important mainly as a pest in dwellings. In Manitoba a heavy infestation of *Neoborus amoenus* (Reut.) occurred on ash at Morden, and near Niagara Falls, Ont., *Poecilocapsus lineatus* (F.) continued to be a serious pest of ornamentals.

ROSE CHAFER.—In the Niagara Peninsula, Ont., *Macrodactylus subspinosus* (F.) commonly attacked peonies, iris, roses, weigelia, and elm.

SATIN MOTH.—Only small numbers of this insect were observed at Kamloops, B.C., and St. Jean and St. Anne de la Pocatiere, Que., but in central Newfoundland large populations persisted, severely defoliating ornamental poplar and willow.

SAWFLIES.—*Pikonema alaskensis* (Roh.) was numerous on ornamental spruce in St. Jean, Que. In Prince Edward Island and Newfoundland, *Pristiphora geniculata* (Htg.) continued to cause extensive defoliation of mountain ash.

SCALE INSECTS.—In a survey of nurseries in the Niagara Peninsula, Ont., *Lepidosaphes ulmi* (L.) was less numerous than in recent years, but light to medium infestations were found on walnut, willow, poplar, mountain ash, and lilac. The juniper scale, *Carulaspis visci* Shrk. (=*Diaspis carueli* Targ.), also occurred in reduced numbers, but was common in light to medium infestations on many species of juniper and arbor vitae. *Aspidiotus perniciosus* Comst. was found on mountain ash in five infestations of varying intensity and *Lecanium* spp. occurred commonly on arbor vitae, juniper, and old trumpet vines. Elsewhere in Canada *L. ulmi* damaged cotoneaster hedges in the Lethbridge, Alta., area and many ornamentals in Prince Edward Island, and the juniper scale occurred on juniper in southwestern Ontario in the most severe infestation on record. In Brandon, Man., *Phenacaspis pinifoliae* (Fitch) was a serious pest on pine, and in Newfoundland *Pulvinaria innumerabilis* (Rathv.) (=*P. vitis* (L.)) was less injurious than in 1955.

SPRUCE BUDWORM.—This insect was reported to be less numerous than in recent years in southern Quebec, Prince Edward Island, and Newfoundland.

TENT CATERPILLARS AND WEBWORMS.—*Malacosoma disstria* Hbn. damaged many poplar trees in Lethbridge, Alta., but in southern Ontario and Quebec *Malacosoma* spp. were at a low ebb. *Hyphantria cunea* (Drury) occurred in small numbers in Brandon, Man., and was much less numerous than in 1955 in eastern Ontario, but in southwestern Quebec populations on elm indicated a definite increase. Light infestations of *Archips cerasivorana* (Fitch) were observed in southern Quebec.

THRIPS.—In northern agricultural areas of Alberta unidentified thrips damaged Virginia creeper and poppies. In Saskatchewan the gladiolus thrips was reported from Yorkton and roses were damaged by an unidentified species at Saskatoon.

A TWIG BORER.—*Xiphydria* sp. was reported for the first time in Saskatchewan when found damaging roses at Saskatoon.

A VARIEGATED FRITILLARY.—*Euptoieta claudia* Cram. damaged pansies at Winnipeg, Gunton, and Brandon, Man.

AN YPONOMEUTID MOTH.—In Ontario larvae of *Swammerdamia caesiella* Hbn. were found feeding on purple leaf plum, *Prunus pissardi*, in several nurseries in Lincoln and Welland counties and were abundant in three orchards. The insect is apparently new to this continent.

INSECTS ATTACKING MAN AND OTHER MAMMALS

BED BUG.—Infestations of the bed bug were reported from Oyama, B.C.; Viking and Calgary, Alta.; Moose Jaw and Saskatoon, Sask.; Winnipeg and Lac du Bonnet, Man.; Ottawa, Ont.; Aylmer, Que.; and Charlottetown and O'Leary, P.E.I.

BITING MIDGES.—At Kamloops, B.C., *Culicoides yukonensis* Hoff. and *C. obsoletus* (Mg.) were the most abundant species, and *C. wirthi* Foote & Pratt was recorded for the first time in the area.

BLACK FLIES.—In the area between Prince George and Smithers, B.C., black flies were a major pest on cattle. In Alberta cattle were attacked by *Simulium arcticum* Mall. in the Vermilion, Wainwright, and Manville areas. In Saskatchewan outbreaks were the most widespread and severe since 1948, *S. arcticum* being the most troublesome species; 19 animals were known to have been bitten. Along the Beaver and Shell rivers *S. venustum* Say occurred in outbreak numbers, seriously affecting livestock and reducing milk production. *S. meridionale* Riley attacked chickens at Moosomin, retarding egg production. In Manitoba black flies were unusually abundant in the Souris River basin and some tributaries of the Assiniboine, five species being recorded in the area. In eastern Ontario black flies were a major pest over an unusually long period, attacking in numbers as late as November 15. In Newfoundland, too, these insects were very troublesome.

BLOW FLIES AND FLESH FLIES.—At Kamloops, B.C., maggots taken from a wound in a man's face were probably of *Phormia regina* (Mg.). At Edmonton, Alta., myiasis in a rabbit was caused by sarcophagid larvae, probably *Wohlfahrtia* sp. At Frenchman Butte, Sask., *Cuterebra grisea* Clark was taken on wild mice. On Bell Island, Nfld., *Phaenicia sericata* (Mg.) continued to cause the usual amount of myiasis in sheep.

BOT FLIES.—*Gasterophilus* spp. continued to be a common pest of horses.

CATTLE GRUBS.—In British Columbia the incidence of warbles continued to be high, although the general population level appeared to be slightly lower than during the previous three years, probably as a result of unfavourable weather during the pupation period in 1955. In Manitoba little change in intensity of infestation was noted. In Ontario organized control measures had greatly reduced populations in many areas.

FLEAS.—*Ctenocephalides* spp. occurred very commonly in household infestations and were widely distributed. Reports were particularly numerous in Ontario. *Ceratophyllus gallinae (Schr.)* attacked humans at Sunny Bank, Que.

LEAFHOPPERS.—Unidentified species of leafhoppers caused considerable annoyance to humans in the Kamloops, B.C., area and at Ottawa, Ont. They commonly bit exposed areas of the body. In British Columbia they were common in sagebrush and in Ontario they appeared to be associated with sweet rocket.

LICE.—In Alberta the spined rat louse, *Polyplax spinulosa* (Burm.), was taken on a rat, the first record of the species in the Province. In Saskatchewan *Polyplax* sp. occurred in a heavy infestation on laboratory rats at Saskatoon. Cattle lice were rather more abundant than usual in Manitoba and Ontario, because of an unusually long stabling period and deterioration in condition of the stock. Chicken lice, although widely distributed and probably fairly common, were only occasionally reported.

MITES.—The chicken mite was reported from Swanson, Moose Jaw, Earl Grey, and Saskatoon, Sask.; Ottawa and Norfolk County, Ont.; and Windsor Mills, Que. In the majority of cases the mites had invaded dwellings, causing annoyance to the inhabitants. The northern fowl mite was reported from Saskatchewan and in Ontario chiggers were reported from Battersea.

MOSQUITOES.—In British Columbia the spring thaw was slow and the runoff steady and moderate. As a result *Aedes* spp. were scarce to moderate in numbers. However, during May and June considerable populations developed in flooded lowlands in the lower Fraser Valley. *Culex tarsalis* Coq. was numerous in irrigated areas of the Okanagan Valley and *C. pipiens* L. invaded dwellings at Cowichan Lake in large numbers during September and October. In Alberta and Saskatchewan mosquitoes occurred in reduced numbers, partly because of control measures. In Manitoba *Aedes* spp. were generally very abundant as a result of the large amount of surface water from heavy snowfall and abundant rains. Control campaigns in the Brandon and Winnipeg areas greatly reduced populations. In eastern Ontario emergence was late, but adults soon became numerous and attacked persistently until October, creating a near-record period of activity. In the Atlantic provinces mosquitoes were very troublesome, but were probably present in about normal numbers.

SNIPE FLIES.—Formerly regarded as pests at higher altitudes, *Symphoromyia* spp., were taken in large numbers at Schram Lake (elevation 350 ft.), near Hope, B.C., and bit freely during the heat of the day. Specimens were taken also at Vancouver and Chilliwack.

TABANIDS.—In Saskatchewan *Tabanus affinis* Kby. was unusually abundant at Melville and Whitewood. In Manitoba, tabanids and chrysopids caused much irritation to livestock and reduction of milk flow in the inter-lake district. In eastern Ontario *Tabanus* spp. and *Chrysops* spp. were greatly diminished in numbers and active over a short period. In Newfoundland normal numbers were reported.

TICKS.—In British Columbia *Dermacentor andersoni* Stiles was very abundant in certain areas of the large cattle grazing fields of the Douglas Lake, Guichon, and Nicola stock ranches.

However, the spraying with BHC of some 7,000 animals ranging on these areas prevented any cases of tick paralysis. Other areas, which for many years had large numbers of ticks, were remarkably free from them. These included Raleigh, Saxon Field, Ashnola, and the Kamloops area. Apparently the tick populations are not necessarily constant, even at sites of heavy rodent populations. One cow in the Quilchena Indian Reserve and four of 40 head at the Willow Ranch, Kamloops, were lost through tick paralysis. Neither of the herds had been sprayed for ticks. One four-year-old girl at Vernon was temporarily, partially paralyzed by one tick. New host records for adults of this tick included groundhogs, pack rats, and ground squirrels. Collections of the ear tick, *Otobius megnini* (Dugès), indicated that it was generally present in native ungulates and in some herds of cattle in the area of British Columbia south of parallel 52 and east of meridian 121. Infestation by this tick killed six cattle and was probably the cause of death in other cases reported. In Saskatchewan an unusually heavy infestation of *Dermacentor variabilis* (Say) at Oxbow was reported to have killed about 20 horses, but malnutrition may have been a greater factor. The species was taken also on children at Whitewood. In Manitoba the heaviest infestation for a number of years occurred in all southern sections of the Province, particularly in the Brandon area, where the ticks were very troublesome to humans. Cattle became heavily infested and in some cases showed considerable loss of flesh as a result. This tick was particularly abundant in brush pastures along the Assiniboine and Souris valleys and in the Brandon Hills. *Ixodes cookei* Pack. was taken on humans near Hull, Que., and on a cat at Norton, N.B. Two infestations of the brown dog tick in dwellings were reported at Ottawa, Ont.

WASPS AND HORNETS.—These insects were widely distributed and bothersome to householders. They were particularly numerous in Manitoba and in one instance damaged ripe strawberries.

HOUSEHOLD INSECTS

ANTS.—Infestations of ants in buildings, lawns, and gardens continued to be widespread and numerous. *Monomorium pharaonis* (L.) was widely reported in Eastern Canada and seems to be increasing in abundance. It occurred as far north as Gander, Nfld., where a heavy infestation developed in airport buildings. *Camponotus* spp. occurred very commonly and infested Ten-Test insulation at Ottawa, Ont.

BOOKLOUSE.—New dwellings were commonly infested by large numbers of booklice in northern Alberta.

BOXELDER BUG.—In southern Ontario overwintered adults were commonly reported in dwellings in early spring, but population build-up during the summer in Ontario and elsewhere in the country was apparently below normal.

CARPET BEETLES.—*Attagenus piceus* (Oliv.) was commonly reported from coast to coast, and in Alberta and Saskatchewan outnumbered all other household pests together. It was apparently less abundant in coastal areas. At Ottawa, Ont., it greatly outnumbered *Anthrenus scrophulariae* (L.). The latter species occurs commonly in Eastern Canada, but is generally less numerous than the former.

CLOTHES MOTHS.—Clothes moths continued to be reported, but in recent years have been fairly well controlled.

CLUSTER FLY.—Hibernating adults of this insect seemed to be more abundant than usual in Ontario.

COCKROACHES.—The German cockroach was commonly reported in all provinces. *Supella supellectilium* (Serv.) was recorded for the second successive year from Edmonton, Alta., and Ottawa, Ont., two infestations being reported in the latter city. In Manitoba, *Blaberus craniifer* Burm. was taken in a building in Winnipeg. *Parcoblatta pennsylvanica* (Deg.) was a common pest in camps and cottages in eastern Ontario.

CRICKETS.—*Ceuthophilus* spp. occurred commonly in basements, frequently in new dwellings. They were numerous in cities of Western Canada and were occasionally reported in the east. *Acheta domestica* (L.) occurred in several buildings in Ottawa, Ont. *Acheta assimilis* F. commonly invaded dwellings in Ontario and Quebec late in the season.

EUROPEAN EARWIG.—This insect was recorded for the first time in Halifax, N.S., when it was found in considerable numbers beneath shingles on an old building.

HOUSE FLY.—This cosmopolitan pest is now fairly well controlled in human habitations in most areas.

MIDGES.—At Glenmore, B.C., in the Okanagan Valley, a heavy flight of *Tanytarsus* sp. in April alighted on exposed laundry and fresh paint and invaded dwellings.

MILLIPEDES.—In many areas of Ontario millipedes invaded motels, garages, basements, and cottages in unusual numbers.

MANURE FLIES.—Species of Borboridae invaded single dwellings in large numbers at Montreal, Que., and Ottawa, Ont.

MITES.—The clover mite was commonly reported from coast to coast, but was somewhat less troublesome than usual in southern agricultural areas of Alberta, Manitoba, and Ontario.

SILVERFISH.—These insects were less frequently reported than in 1955, but in Ottawa, Ont., continued to occur commonly in new buildings, especially apartments.

STRAWBERRY ROOT WEEVIL.—This widely distributed household invader was particularly annoying in Saskatchewan, Ontario, and Quebec.

TERMITES.—Infestations of termites were reported from Ashcroft and Summerland, B.C., and Toronto, Ont.

A WINTER CRANE FLY.—*Trichocera* sp., seldom reported, occurred in large numbers in a vegetable store room at Gaspé, Que.

WOOD BORERS.—Powder-post beetles, anobids and *Lyctus* spp., continued to be troublesome, mainly in coastal areas and near the Great Lakes. The linden borer, *Saperda vestita* Say, emerged from firewood in Fort Garry, Man. *Nacerdes melanura* (L.) occurred in dwellings at Winnipeg, Man., and Meaford, Ont. *Trypopitys sericeus* (Say) damaged flooring and timbers in a dwelling in Charlottetown, P.E.I. Cerambycids cut emergence holes in the plasterboard walls of new buildings in St. Jean, Que., Hull, Que., and Ottawa, Ont., and appeared in large numbers in a dwelling at Fawn, B.C.

STORED PRODUCT INSECTS

STORED GRAIN INSECTS.—In the Prairie Provinces there was a marked decrease in the number of reported infestations in grain in farm storage and country elevators as compared with 1955. This was attributed mainly to favourable harvest weather, which resulted in grain being stored with a lower moisture content than in recent years. The rusty grain beetle occured in grain samples more frequently than any other species, next in frequency of occurrence being *Cephalonomia waterstoni* Gahan, a parasite often associated with heavy infestations of this beetle. These were followed by fungus beetles (*Crytophagus* spp. and *Lathridius* spp.), psocids, and various grain mites. *Cryptophagus* spp. were found chiefly in grain stored for a year or longer in temporary grain annexes. Insects found in isolated infestatations included the meal moth, hairy spider beetle, yellow mealworm, saw-toothed grain beetle, granary weevil, red flour beetle, foreign grain beetle, Mediterranean flour moth, the flour beetle, *Tribolium madens* (Charp.), and dermestids.

MILL AND WAREHOUSE INSECTS.—In a survey of flour warehouses in Manitoba, the hairy spider beetle was found to be the most widely distributed and the most serious pest. Insects commonly found in stored seed included the rusty grain beetle, fungus beetles, psocids, and mites. In Winnipeg, Man., the black carpet beetle heavily infested stored seed in a warehouse and laboratory and a flat grain beetle, *Laemophloeus turcicus* Grouv., was found in mill machinery. *Trogoderma inclusum* Lec. (=*T. versicolor* of American authors) was found in stored seed in Winnipeg, Man., and Mendham, Sask.

FOOD-INFESTING INSECTS.—The following insects occurred commonly in stores and dwellings in most areas of Canada: Indian-meal moth, larder beetle, saw-toothed grain beetle, confused flour beetle, red flour beetle, *Tribolium destructor* Uytten., meal moth, yellow mealworm, dark mealworm, bean weevil, drug-store beetle, black carpet beetle and various spider beetles. An infestation of the cheese skipper occurred in broken tins of corned beef at Winnipeg, and in Quebec the appearance of booklice in sugar sold in paper bags was traced to a rather severe infestation in the mill where the bags were made.

MISCELLANEOUS.—In Saskatchewan the red flour beetle occurred in abundance in hammered oat straw, oat sheaves, and oat chop at Moose Jaw, Pambrun, and Kincaid, respectively. At Pambrun an infestation also occurred in a house. This species was first recorded in the Province in 1955 and is now apparently widespread in southern Saskatchewan. At Kamloops, B.C., an oriental species of weevil, *Sepalus hypocritica* Boh. was found in a box of Japanese oranges.

NOTES ON NEMATODES

The cyst nematodes (*Heterodera* spp.) are all generally classified as important crop pests. They are all capable of causing damage to some crops and they are extremely difficult to control. The sugar-beet nematode, *H. schachtii* Schmidt, 1871, and the oat-cyst nematode, *H. avenae* (Lind, Rostrup & Ravn, 1913) Filipjev, 1934, have both been previously reported from Ontario in areas that do not overlap. There was no indication in 1956 of any marked spread of either of these pests. Another species, *H. punctata* Thorne, 1928, previously called the wheat nematode because it was found in wheat in the Prairie Provinces, should more correctly be referred to as the grass cyst nematode. In Europe, where it has been reported fairly frequently, it has been found only on grasses. Surveys of wheat fields in Saskatchewan where it was originally found failed to disclose it again on this crop. New records for this species were from Cap Tourmente, Que., where roots of bentgrass, *Agrostis palustris* Huds., were heavily infested, and from Lethbridge, Alta., where it was found in prairie grass sod. Records in Canada of the clover cyst nematode, *H. schachtii* var. *trifolii* Goffart, 1932, continued to accumulate, indicating that this nematode may be fairly common in this country.

The northern root-knot nematode, *Meloidogyne hapla* Chitwood, 1949, was found at Hemmingford, Que., and Pembroke, Ont., attacking carrots; in a nursery at Toronto, Ont., on roots of *Viburnum* sp. and *Philadelphus coronarius* L.; at Ottawa, Ont., on alfalfa; and at Cap Tourmente, Que., on red clover. The southern root-knot nematode, *Meloidogyne incognita* (Kofoid & White) Chitwood, 1949, was found at Macdonald College, Que., on red clover (in

greenhouse); at Saskatoon, Sask., on roots of *Coleus* sp. (in greenhouse); and on roots of violet plants intercepted from Hong Kong, China. It is not yet clear whether this species can overwinter in the field in Canada.

During 1956 the potato-rot nematode, *Ditylenchus destructor* Thorne, 1945, was found in only one field in Prince Edward Island not previously reported, and this field was in an area in which this species was known to occur.

Stunt nematodes (*Tylenchorhynchus* spp.) appear to be fairly common in Canada. *T. magnicauda* (Thorne, 1935), Filipjev, 1936, was found at Summerland, B.C., in grass sod; *T. acutus* Allen, 1955, at Farm Kane, Man., on crested wheat grass and at Wild Horse, Alta., on alfalfa; *T. lenorus* Brown, 1956, at Hilton, Man., in grass sod, and at Cardston, Alta. on wheat; *T. leptus* Allen, 1955, at Fort Macleod, Alta., in pasture sod; and *T. maximus* Allen, 1955, at Twin Butte, Alta., on alsike.

Up to the present the most common root-lesion nematode in Canada appears to be *Pratylenchus penetrans* (Cobb, 1917) Sher & Allen, 1953. New records for this species were from Ottawa, Ont., on the fine roots of apple trees and on raspberry; also, it was intercepted on lily-of-the-valley pips from Germany. *P. pratensis* (deMan, 1880) Thorne, 1949, was found at Cap Tourmente, Que., in grass sod; and *P. vulnus* Allen & Jensen at Medicine Hat, Alta., on roses (in greenhouse) and on raspberry plants from France.

The grass seed gall nematode, *Anguina agrostis* (Steinbuch, 1799) Filipjev, 1936, has been encountered frequently in Canada and at least some of these infestations probably originated in imported grass seed. New records were from Toronto Island, Ont., on Kentucky blue grass; from Colebrook, B.C., on red top grass; and interceptions were made on bentgrass seed from Minnesota, U.S.A., and brown top seed from New Zealand.

New records of the ectoparasitic ring nematodes (*Criconemoides* spp.) included the following: *C. lobatum* Raski, 1952, on red clover at Ottawa, Ont., and Cap Tourmente, Que.; *C. curvatum* Raski, 1952, in pasture sod at Fort Macleod, Alta.; and *C. xenoplax* Raski, 1952, on white elm at Ottawa, Ont.

New records of ectoparasitic dagger nematodes, *Xiphinema* spp., were as follows: *X. americanum* Cobb, 1913, at Ottawa, Ont., in large numbers on the roots of white elm; at Lethbridge, Alta., on alfalfa; at Hilton, Man., and Carmel, Sask., in grass sod; and at Summerland, B.C. in lawn sod. *X. diversicaudatum* (Micoletsky, 1927) Thorne, 1939, was found at St. Bruno, Que., on rose roots that were severely galled and stunted.

Radopholus gracilis (deMan. 1880) Hirschmann, 1955, was reported from mud flats of Cap Tourmente, Que., infesting the roots of bulrush, *Scirpus americanus*. *Longidorus elongatus* (deMan. 1876) Thorne & Swanger, 1936, was numerous in lawn sod at Ottawa, Ont. *Aphelenchoides ritzema-bosi* (Schwartz, 1911) Steiner, 1932, infested the foliage of *Chrysanthemum* sp. at Sarnia, Ont., and a species of *Trichodorus* was numerous in soil around rose roots at Ottawa, Ont.

Records of predacious nematodes belonging to the genus *Mononchus* included the following: *M. incurvus* Cobb, 1917, from St. Bruno, Que., near rose roots; *M. macrostoma* (Bastian, 1865) Cobb, 1916, from Blackburn Station, Ont., in soybean field; *M. lacustris* (Cobb, M.V., 1915) Cobb, 1917, from Richmond, Ont., in soil near wild rice growing in water; *M. longicaudatus* (Cobb 1983) Cobb, 1916, from Richmond, Ont., near wild rice roots; from Picture Butte, Alta., in riverside soil and from Summit, Princeton, B.C., in streamside soil. *M. parvus* (deMan, 1880) Cobb, 1916, was found at Victoria, B.C., in orchard grass soil; *M. papillatus* (Bastian, 1865) Cobb, 1916, at Kamloops, B.C., in grass sod, and at Vernon B.C., in soil from an apple orchard. *M. muscorum* (Dujardin, 1845) Cobb, 1916, was found at Richmond, Ont., near wild rice growing in water; at Ottawa, Ont., in grass sod; and at Fredericton, N.B., in grass sod. *M. brachyuris* (Buetschli, 1873) Cobb, 1917, was recorded from Point Pelee, Ont., in soil from an apple orchard; from Cyrville, Ont., in pasture sod; from Ottawa, Ont., in clover soil; and from Cap Tourmente, Que., in clover soil.

Records of identifications of nematodes from new hosts and new localities in Canada are published periodically in *The Canadian Insect Pest Review*.

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V. THE SOCIETY

PROCEEDINGS OF THE NINETY-THIRD ANNUAL MEETING OF THE ENTOMOLOGICAL SOCIETY OF ONTARIO

2 November, 1956.

The 93rd annual meeting of the Entomological Society of Ontario was held in War Memorial Hall, Ontario Agricultural College, Guelph, Ontario on Friday, 2 November, 1956.

Registration began at 9:00 a.m. and the meeting was opened at 9:30 a.m. R. H. Ozburn, President of the Society, welcomed the members and friends of the Society.

At the request of the members the Presidnet named the following committee:

Nominations Committee

R. Glen, Chairman
G. F. Manson
A. J. Hall

The President then turned the chair over to Dr. Glen who introduced the session "Highlights of the Congress." The speakers brought out highlights in various fields as they had been presented at the Congress and during a "Discussion Period" many opinions were expressed from the members.

The annual business meeting was held at 2:00 p.m. and following a motion by H. W. Goble seconded by G. G. Dustan the minutes of the previous meeting were adopted as read.

The financial statement for the year ending 29 October, 1956 was presented by the Secretary-Treasurer. It was moved by W. C. Allan and seconded by H. R. Boyce that the statement be approved.—Carried.

The Secretary then informed the members of the outstanding items of business arising from a Board of Directors meeting which had taken place 1 November, 1956.
Namely that:

1. A committee would be formed in an effort to increase membership in the Society.
2. A mail ballot was being considered and that this subject would be brought before the members at the next annual meeting.

The President then asked for the report of the Nominations Committee. The chairman reported as follows:

Directorate

A. S. West, Kingston
G. G. Dustan, Vineland Station
A. G. McNally, Guelph
J. B. Thomas, Sault Ste. Marie
L. A. Miller, Chatham
H. L. House, Belleville
L. L. Reid, Ottawa

Auditors

R. C. Cooke, Guelph
C. J. Payton, Guelph

Moved and seconded that nominations close—motion carried.—Slate as stated.

The President announced that the next annual meeting would be held in Kingston 31 October, 1 and 2 November, 1957.

The meeting then adjourned.

During the afternoon session lively discussion followed a paper by A. S. West entitled "Training the Entomologist."

The remainder of the afternoon was given to paper reading as per programme.

The chairman for this session, G. F. Manson, thanked all the speakers and asked for an expression of appreciation to the O.A.C. for the facilities and services which had been made available to the Society.

At the conclusion of the session the President declared the Ninety-Third Annual Meeting of the Society adjourned at 5:32 p.m.

W. C. Allan,
Secretary-Treasurer.

ENTOMOLOGICAL SOCIETY OF ONTARIO
GUELPH - CANADA

RECEIPTS		EXPENDITURES	
Dues	$ 996.00	Printing Can. Ent.	$1,094.00
Back Numbers	4.92	Bank Exchange	1.92
Grant	300.00	Library Assistance	150.00
Bank Interest	8.46	Binding	3.51
		Postage	50.00
	$1,309.38	Steno. Assistance	10.00
Bank Balance		Auditing	5.00
Oct. 29/55	437.44	Envelopes	22.56
		Bank Balance	
	$1,746.82	Oct. 31/56	409.83
			$1,746.82

Auditors
R. C. Cooke
C. J. Payton

W. C. Allan,
Secretary-Treasurer.
October 29, 1956.

Statement of Finances as presented to the members at the Annual Meeting, November 2, 1956.

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VI. INDEX

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It is believed that all well-known species mentioned in Sections I, II, III are listed here. Others may be found by referring to the crop, habitat or locality.

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ANNUAL REPORT

OF THE ENTOMOLOGICAL SOCIETY OF ONTARIO

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3. In order to make the "Literature Cited" of maximum possible benefit to entomologists in many parts of the world to which the Annual Report is sent, references should be listed alphabetically as follows:

Reference number in brackets, surname of author in capitals, initials of author, date in brackets, full title of paper as given by the author, a dash, name of the journal abbreviated according to the system adopted in the "World List of Scientific Periodicals", volume number underlined, colon, number of the first page of the article, period.

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5. Material accepted for publication in the Annual Report normally should not have been and should not subsequently be published elsewhere.

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ANNUAL REPORT of the ENTOMOLOGICAL SOCIETY OF ONTARIO

Volume Eighty-Eight

1957

(Published October, 1958)

PUBLISHED BY AUTHORITY OF
THE HONOURABLE WILLIAM A. GOODFELLOW, MINISTER OF AGRICULTURE FOR ONTARIO

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of the
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Volume Eighty-Eight

1957

(Published October, 1958)

Published by authority of

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The Ninety-Fourth Annual Meeting of the Society was held at Queen's University, Kingston, Ontario, on October 31 and November 1, 1957.

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GENERAL INFORMATION

Authors are entirely responsible for statements in their articles in the Annual Report, whether of fact or opinion.

I. INVITATION PAPERS

DEVELOPMENTS IN RESISTANCE OF PLANTS TO INSECTS[1]

JACQUES L. AUCLAIR[2]

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INTRODUCTION

Observations on resistance of plants to insects date as far back as the earliest days of economic entomology. In America, Havens (32) in 1792 reported the Underhill variety of wheat as resistant to the hessian fly, *Phytophaga destructor* (Say), and Packard (61) in 1880 stated that: "Of the different varieties of fly-proof wheat, the Underhill variety has for nearly a century been highly recommended". Similar observations were subsequently reported, and a classic example was the case of the grape phylloxera, *Phylloxera vitifoliae* (Fitch), in France, which was controlled by the use of phylloxera-resistant vines from America (64). This method is still apparently an important means of control of this insect. With the accumulation of knowledge on resistance of plants to insects, review papers appeared periodically, an important one being that by Snelling (76), with 567 references, and a bibliography (1) listing 518 references. According to Snelling (76), only 37 papers reporting resistance were published during the 128 years before 1920, but publications then increased considerably. In 1951, the first book on insect resistance in crop plants was published by Painter (64). This book contains a comprehensive review of the literature up to 1950, a discussion of general principles and over 1,000 references. Painter has recently completed a review paper on the subject to appear in the third volume of the Annual Review of Entomology.

Investigations on resistance of plants to insects have been centred on three main aspects: (a) A considerable number of plant varieties and species showing resistance to insects have been reported, usually from field observations on the densities of the insect populations. Snelling (76) mentions nearly 100 such plant species representing most major groups, such as cereals and grasses, legumes, garden and truck crops, fruits, ornamentals, forest trees, and single species such as cotton, sugar cane, tea, and coffee. (b) Field observations were often followed by screening tests to determine the occurrence of resistance in species and varieties, and this in many cases was followed by plant breeding investigations for the development of resistant plants. This implied that the resistance may be transmitted genetically, and the early plant breeding work amply demonstrated this fact (e.g., 5, 18, 19, 25-27, 36, 57, 58, 66-69). Important breeding work has been carried out in wheat, corn, cotton, sorghums, potato, peas, and other plants, and the economic results in general have been satisfactory (64). The importance of considering resistance to insects and disease in any sound plant breeding program has been accepted by agronomists and horticulturists as shown by entire chapters now devoted to the subject in books on plant breeding (e.g., 35). (c) Concurrently with the plant screening and breeding work, investigations were carried out in the field, greenhouse, and laboratory toward a closer analysis of the insect-plant relationships for susceptible and resistant plants. This subject is covered below under "Mechanisms of resistance".

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[1]Contribution No. 3767, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada; presented as an invitation paper to the 94th annual meeting of the Society at Kingston, Ontario, October, 1957.

[2]Entomologist

Painter (64) defines resistance of a plant to an insect as *the relative amount of heritable qualities possessed by the plant which influence the ultimate degree of damage done by the insect.* In practical agriculture it represents the ability of a certain variety to produce a larger crop of good quality than do ordinary varieties at the same level of insect population. From the above definition, the resistance of a variety is *relative* and is determined only by comparison with less resistant or more susceptible varieties. In varieties of a plant species, there are therefore degrees of resistance varying from *immunity,* when a variety is never injured by a specific insect, (examples of immunity are rare) to *high resistance, low resistance, susceptibility,* and, finally, *high susceptibility,* when a variety shows much more than average damage from a specific insect.

This is a short review of general principles in the study of resistance of plants to insects and of some recent developments concerning the physiological factors of resistance.

MECHANISMS OF RESISTANCE

Painter (63, 64) recognized at least three principal aspects or mechanisms of resistance on the basis of the insect and plant reactions (Fig. 1). The arrows that Painter showed between the three names have been replaced by simple lines since it is very possible that antibiosis may be the first resistance mechanism influencing the insect (through feeding) to a non-preference reaction. One, two, or the three mechanisms are often operating in the same resistant variety. It may, however, be difficult in certain cases to separate resistance into these three components. The converse mechanisms in a susceptible plant would be: Preference (64), probiosis, and intolerance.

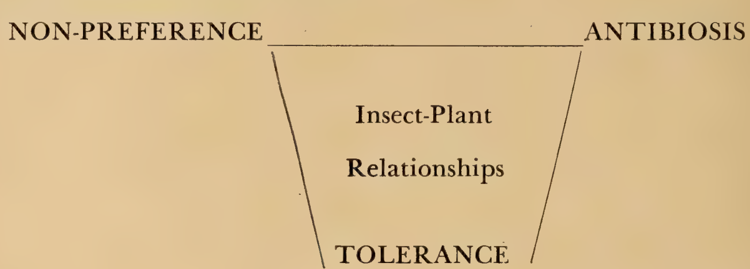

Fig. 1. Mechanisms of resistance of plants to insects (from Painter (64), with slight modifications).

Tolerance concerns primarily the plant, and means that the plant can grow and reproduce itself and/or repair injury in spite of supporting an insect population that would damage a more susceptible host. For instance, the stunting of plants from sucking insects may be more pronounced on some varieties of alfalfa susceptible to the pea aphid, *Acyrthosiphon pisum* (Harr.), than on more tolerant varieties. The low degree of stalk breakage produced in certain corn and wheat varieties by the European corn borer, *Pyrausta nubilalis* (Hbn.), and the wheat stem sawfly, *Cephus cinctus* Nort., may be, to a certain extent, other examples of tolerance (64).

Non-preference means that insects are kept away from, or at least are not attracted in a significant degree to, a particular plant for oviposition, food, or shelter. This definition implies more than would be implied by *repellence* or *host avoidance.* This basis of resistance encompasses indeed the field of host selection in phytophagous insects, and this field has been reviewed recently (e.g. 20, 21, 41, 51, 65, 79, 80). The latest aspect of host selection by phyto-

phagous insects has been centred on whether selection is governed primarily by the nutritional superiority of the plant or region of the plant serving as food for the insect, or by the presence or absence in plants of attractants or repellents that are often of little if any nutritive value but to which the parasitic species has become adapted. This *dual discrimination theory,* well stated by Kennedy and Booth (42) for aphids, may operate in many insects. Observations and experiments by other workers (e.g. 6, 48, 79) support the contention that insects provided with diets of superior nutritional value may prefer such diets and may respond by an increased rate of feeding. Thorsteinson (79) has also shown that token stimuli apparently evoke maximum sensory reactions on a ration of maximum nutritive value. There are several examples of non-preferred plant varieties: recently Cartier and Painter (16) demonstrated non-preference by alate forms of the corn leaf aphid, *Rhopalosiphum maidis* (Fitch), for some varieties and hybrids of sorghums.

Antibiosis, a term proposed and defined by Painter (63), concerns primarily the plant, and involves those adverse effects on development of the insect that result from the use of the resistant plant as food. These effects on the insect are usually reduced fecundity, decreased body size and weight, abnormal length of life, or increased mortality. Some authors would reserve the term *resistance* for those plants that show antibiosis. This resistance mechanism is concerned primarily with the physiological factors in resistance of plants to insects, and comparatively little progress has been achieved in this field, for various reasons. One of these may be the complexity of the problem, which usually requires research by groups of specialists in fields such as insect and plant physiology, nutrition, and biochemistry as well as genetics. As recently as 1951, Painter (64) stated that, because of the scarcity of experimental facts, suggestions of a physiological basis of antibiosis must be regarded as tentative. In the past, success in plant breeding for resistance to insects has been ensured mostly by collaboration between entomologists, horticulturists, and plant breeders, and such collaboration might be extended to include specialists in insect and plant physiology and biochemistry. A better knowledge of the factors in resistance would be valuable to the geneticist and the plant breeder in their attempts to differentiate the several genetic factors that may be involved (as demonstrated in a recent paper by Beck (10)). A knowledge of the factors in resistance would be of great scientific value to botanists and entomologists, chiefly specialists in insect and plant physiology and nutrition, and to ecologists.

SOME RECENT DEVELOPMENTS CONCERNING ANTIBIOSIS

This section concerns the significance of a few recent studies on antibiosis in resistant plants, including some investigations in progress at the St. Jean laboratory.

Insects may feed on resistant plants, but many of the effects of antibiosis suggest that the food that is ingested contains toxic substances and/or is not satisfactory in quality or in quantity or both for a normal rate of growth, development, and reproduction. It is evident that methods for rearing phytophagous insects on artificial or, even better, on chemically defined diets would provide a most useful tool in such studies. Also, a knowledge of the qualitative and quantitative nutritional requirements of the insects would be most desirable. Progress is being made in this field (e.g. 11, 13, 14, 23, 24, 38-40, 71, 81-83), but information, especially on the quantitative nutritional requirements of phytophagous insects and even of insects in general, is still very fragmentary (11, 33, 37, 47-51, 70).

Beck (7, 8) and Beck and Stauffer (12) recently gave an example concerning the nutrition of the European corn borer in relation to its principal host plant. Using a method of artificial feeding (11, 14), Beck and his co-workers demonstrated the existence in the corn plant of several resistance factors. When these factors were added to purified diets fed to the borer, the borer suffered a decrease in growth and an increase in mortality. The resistance factors occurred in larger amounts in the whorl leaves of younger corn plants, which are known to exhibit resistance to the borer, and also in the more resistant corn inbreds. Beck (10) showed that the relative resistance factor activity in the leaf tissue of the whorl of the resistant inbred W22 and the susceptible inbred WF9 decreased as tassel length (and age of plants) increased in both varieties, indicating intra-varietal differences, and the resistance factor activity throughout was approximately twice as high in W22 as in WF9, indicating inter-varietal differences in resistance. Beck (9) demonstrated that when the resistance factors were added to purified diets, the inhibitory activity of resistance factor A toward the larvae was inversely proportional to the glucose content of the diet. From such findings, the author postulated that the saccharotrophism exhibited by the borer larvae on corn plants (7), whereby the larvae in nature oriented themselves and fed mostly on those parts of the plants higher in sugar content, had a major biological function in the survival of the larvae by offering them "nutritional" protection against the action of resistance factor A. Resistance factor A was isolated (52), and its chemical identity was established (74) as an organic compound of four chemical elements ($C_8H_7O_3N$) called 6-methoxy-benzoxazolinone. This compound was shown to be deleterious to several insects and fungi. In a recent report, Beck (10) established the presence in corn of at least three resistance factors, A, B, and C, and postulated that the resistance of corn to different attacking organisms (European corn borer; corn leaf aphid; corn earworm, *Heliothis zea* (Boddie); the fungus *Fusarium)* has a common basis and that its manifestation depends on (a) concentrations of resistance factors in the tissues, (b) association between distribution of the resistance factors and establishment sites of the parasitic organism, in other words, association in time and space between the resistance factors and the feeding of corn plant parasites, and (c) sensitivities of the infesting organisms (insects or pathogens) to the resistance factors.

Several investigators, especially in Europe, have studied resistance of potato varieties and species to the Colorado potato beetle, *Leptinotarsa decemlineata* (Say) (e.g. reviews by Chin (17) and Painter (64)). Some resistance factors were isolated chiefly by chromatographic methods and were identified as alkaloid glycosides, such as tomatine (from tomato plants) and demissine (from *Solanum demissum* Lindl, a potato species resistant to larvae) (44-46). These substances inhibit larval growth, and at least part of the resistance of *S. demissum* has been attributed to the presence in potato leaves of sufficiently high concentrations of demissine. Kuhn and his associates (46) showed that the resistance factors in potatoes and tomatoes likewise affected adversely the growth of some microorganisms just as reported by Beck and his co-workers in their studies on the corn resistance factors. Such findings confirm Beck's postulate (10) that resistance to several insects and microorganisms in a single plant species or variety is not only possible but may have a common basis.

Another example of antibiosis and the need for a method of artificial feeding arose from investigations in progress at the St. Jean laboratory on the resistance of varieties of peas, *Pisum sativum* L., to the pea aphid, *A. pisum*. Earlier investigations (28, 31, 53, 54, 72, 73) and more recent unpublished work by the author and Messrs. J. B. Maltais and J. J. Cartier, showed that,

in the field, pea varieties differ in degree of infestation and in rate of aphid increase, and, in the greenhouse, in rate of aphid growth and reproduction. One experimental procedure followed in the greenhouse by Cartier (unpublished) consists in placing one or three parthenogenetic aphids [biotype R1 (55), Cartier (15)] per plant on four replicates of each of several varieties and weighing the progeny that reach the adult stage after nine to ten days. When aphids were reared on the variety Perfection, the average weight of 10 adults was 41.3 mg.; on the varieties Melting Sugar and Onward, only 29.9 and 29.5 mg. Aphids reared on the varieties Champion of England and Laurier had intermediate weights, a weight difference of 3.8 mg. being significant at the five per cent level. Similar results were obtained in a second experiment, performed one year later with the same varieties. Other results showed that the rate of aphid reproduction is usually proportional to the weight of aphids.

By a method (2) for measuring the *rate* and *frequency* of excretion of aphids feeding on pea varieties, close to 2½ times as many droplets were excreted by adults feeding on the susceptible variety Perfection as by those on resistant ones (Melting Sugar, Onward), or 5.7 droplets per aphid per ten hours in comparison with 2.4 and 2.3. Aphids on the semi-resistant varieties (Champion of England, Laurier) gave intermediate excretory values. Largely similar results were obtained in measuring the rate of aphid excretion, 2½ times as much honeydew being excreted by aphids on the susceptible variety Perfection as by those on the resistant ones (Melting Sugar, Onward), or 0.74 microliter per aphid per ten hours in comparison with 0.31 and 0.29. In subsequent experiments, largely similar results were obtained with nymphs. The differences were significant at the one per cent level between the varieties Perfection and Onward or Melting Sugar, and at the five per cent level between Perfection and Champion of England or Laurier. If the rate of excretion is proportional to the rate of feeding, or at least is a good indication of the rate of feeding, it may be concluded that the rate of feeding on resistant varieties is significantly lower than that on susceptible ones.

Although the aphids reared on the resistant varieties produced smaller adults, suggesting that they excrete and feed less because they are smaller, the results of another experiment indicated that irrespective of body weight the rate of excretion decreases as soon as the aphids are placed on a resistant plant. For instance, when third instar nymphs were placed on the resistant variety Melting Sugar, and although their mean weight was slightly greater than those placed on the susceptible variety Perfection (1.02 mg. in comparison to 0.98), their rate of excretion decreased considerably (0.096 microliters per aphid during the first 10 hours on Melting Sugar and 0.568 on Perfection). Therefore, aphids placed on resistant varieties excrete and feed at a lower rate, and this is certainly influential in the production of smaller adults which in turn reproduce at a lower rate.

What factors may be influential in producing this lower rate of aphid excretion and feeding on resistant varieties? If most environmental factors are excluded, since they were standardized as far as possible in the experiments reported, the rate of feeding may certainly be influenced by the aphid itself and by the plant. Kennedy and Booth (42) postulated a *dual discrimination theory* in which host plant selection may be governed in part by the nutritional superiority of the plant or region of the plant serving as food for the insect. Such a theory may be expanded to imply that insects (in this particular case aphids) feeding on plant material of superior nutritional value may physiologically respond by an increase in their rate of feeding. That susceptible varieties of peas

represent plant material of superior nutritional value, at least as far as nitrogenous matter is concerned, has been established (3, 4, 55, 56). The pea aphid feeding on a susceptible variety excretes a honeydew with a slightly higher concentration of free amino acids than that from aphids feeding on semi-resistant and resistant ones. Maltais (unpublished) has demonstrated also that the growth of aphids and their frequency of excretion are increased when they are feeding on pea stems dipped in nutrient solutions of amino acids, peptides and B-vitamins, as compared with checks dipped in water.

On the other hand, the plant may perhaps influence in an important manner the rate of aphid feeding. It has been assumed generally that the normal uptake of plant sap by aphids is the direct result of suction. However, as early as 1914, Zweigelt (85) questioned this assumption and suggested that forces within the plant, set up by or even independent of the insect (aphids or coccids) assisted in the feeding process. Yust and Fulton (84) observed exudation of plant sap from the stylet stumps left embedded in lemon fruit after the coccids had been removed. More recent works by Kennedy and Mittler (43) and Mittler (59) on the willow aphid, *Tuberolachnus salignus* (Gmelin), have shown that if the rostrum of an aphid feeding on a plant is severed, an exudate appears at the tip of the stylet stump remaining in the plant tissues, and this exudation may continue for several days. The aphid having been removed, this exudation evidently is produced by pressure within the plant. The rate of stylet-stump exudation was measured and found to be of one to two microliters per hour and similar to the rate of excretion. Furthermore, after estimating the length of the stylets, the radius of the food canal within the stylets, and the viscosity of the sap exudate, the laws of Poiseuille were applied, and the pressure required to maintain the measured rate of flow through the stylet food canal of a feeding adult aphid was estimated at 20 to 40 atmospheres. Osmotic pressures of those magnitudes exist in plants (e.g. 22, 60), and, at full turgor of the plant, it is assumed that the osmotic pressure is equal to the plant turgor pressure. Mittler (59) suggests therefore that aphids depend on the natural turgor pressure of their host plant for their normal feeding, which pressure is operative in forcing sap up the stylet food canal. The generally accepted view that an aphid's normal mode of feeding is by suction alone is therefore certainly debatable. In view of our results showing differences in rate of aphid excretion (and feeding) on pea varieties, one may speculate that those differences may be due in part to differences in the osmotic (and turgor) pressure of different varieties and that therefore the rate of aphid feeding is to some extent regulated by the plant.

In ending this discussion, a brief mention of biotypes (or races, strains) in insects is pertinent since they are bound to complicate the study of the causes of resistance, as such biotypes may behave somewhat differently on the same plant variety. The existence of biotypes within insect species has been recognized for a long time and many biological strains of insects with slightly different physiological reactions, but with usually little if any morphological distinctions, have been described (e.g. 75, 77, 78). The first study of biotypes in connection with plant resistance to insects was apparently made by Painter (62). The significance of such biotypes in the study of host plant resistance has been discussed by Hayes (34) and evidence on the complexity of the subject is accumulating (e.g. 15, 16, 29, 30). According to Painter (64), there appear to be at least two general types of biological races in insects in so far as resistance in plants is concerned. One type, such as described in aphids by Harrington (29, 30) is merely a larger, more vigorous strain with greater biological potentialities. The other type, as illustrated in the hessian fly, is physiologically adjusted in some way to specific elements of the plant physiology.

ACKNOWLEDGMENTS

The author is indebted to his colleagues Mr. J. B. Maltais, and Dr. J. J. Cartier for advice in the experimental work and in preparing the manuscript. The technical assistance of Mr. St. Georges Morin is also gratefully acknowledged.

SUMMARY

A short review of some general principles involved in the study of resistance of plants to insects is made and some recent developments on the physiological factors of resistance in a few plants are discussed.

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(Accepted for publication: May 22, 1958)

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SOME POSSIBLE SOURCES OF DENSITY DEPENDENCE AND THE EFFECTS OF WEATHER ON NATURAL POPULATIONS*

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ABSTRACT

The classic distinction between natural control factors which are density dependent and those which are density independent may not in fact afford a useful model on which field analysis can be carried out. It has been recognized for some time that weather can appear to show density dependence. This apparent effect probably springs from one of a relatively small number of sources. Under conditions of climatic stress, competition for living space may be intensified. Since such competition is distinctly a density dependent phenomenon, the apparent effect of the weather will vary with the density of the population on which it is operating.

Weather, as well as affecting populations of insects, has a direct effect on the biological substrate which supports those populations. The interaction between a phytophagous population and its substrate involves a direct feed-back which is necessarily density dependent, this dependence in turn affects one side of the relationship between weather and the substrate. The latter relationship

*An abstract of a paper delivered at the 94th Annual Meeting of the Entomological Society of Ontario, as an invitation paper.

of course involves no feed-back. From this, we see that weather may appear to be acting in a density dependent manner, simply as a function of its effect on one side of a density dependent situation.

A similar stricture may be applied in the interpretation of weather on compound populations consisting of a host and various supported parasites. Here, although it is obvious that the weather will affect both the host and parasite, it is not always true that these effects will always be equivalent. However, a weather effect which occurs through the mechanism of parasite population modification will inevitably show some of the characteristics of density dependence resulting from such dependence on the part of the parasite.

On this basis it may no longer be useful to conduct analysis which is designed simply to elucidate direct relationships between insects and the weather. Rather, the weather should be regarded as only one of a complex of factors influencing populations. Since the interaction between weather and other factors may be more important from the viewpoint of population dynamics than is the direct weather effect, it is important that bioclimatogical investigations be designed in such a way that the elucidation of interactions as well as direct effects is possible.

(*Accepted for publication*: *30 May 1958*)

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PHYSICAL SCIENCES IN ENTOMOLOGICAL RESEARCH[1]

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Perusal of entomology literature reveals that considerable research is being done in which the disciplines of chemistry, physics and mathematics are being applied. Moreover, this type of research is being initiated by people trained essentially as entomologists and in many cases they are working independently.

It is a fact that entomology has under its canopy the study of the largest Class, and the number of entomologists is relatively small. The scientist who is concerned with vertebrates can afford to specialize — he may pick one species and one phase, knowing that other species and other phases will be looked after. The entomologist cannot afford this luxury.

This means that the entomologist must be trained in a broader fashion, and the ideal situation is for him to have at his elbow the specialist whom he could call upon for help and guidance. If the problems confronted by entomologists are to be solved they must be extended to cellular and sub-cellular levels where the sciences of chemistry and physics find fruitful application.

It would be ideal if the entomologist was master of all disciplines. Failing this, and very few of us can reach this height, it becomes necessary to put forth a cooperative effort.

[1]Presented to the 94th Annual Meeting of the Society at Kingston, Ontario, October, 1957, as an invitation paper.
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For example, I read an article in *Nature* recently in which Dr. Williams from Harvard reported the preparation of a hormone, allegedly secreted by the *corpus allatum.* This hormone governs metamorphosis of the pupa. He mentioned the possibility of this material being used as an effective insecticide. It would appear to have the ideal property of specificity. This is an example where the organic chemist could be called upon to exert his skill in isolation, characterization and eventual synthesis.

Until a few years ago the efforts made to study the chemistry of the insect were relatively few. There were good reasons for this, one of which was that entomologists were not trained in that direction, and chemists were not lured into the field.

Scientists interested in insects realized full well that enzyme systems within tissues and cells, and chemical changes going on within an insect, are as much a part of the beast as its morphology, its life cycle, its place in the classification scheme or its habits. In fact, from the point of view of the economic entomologist, the chemical aspects of insect life are probably more important than any other.

As a result, within recent years, there has been an upsurge in the application of physical sciences to a study of the Insecta. A brief look at these applications may provide food for thought to those who fear to tread.

A number of years ago when nutritionists extended their enquiries to the insect world, or more aptly when entomologists became interested in the nutrition of insects, experiments revealed that a sterol was a nutrient required by many insects. Sterols are fat-soluble components of plant and animal matter which have as their basic structure a phenanthrene nucleus. Plants and higher animals synthesize their sterols — it appears then that insects do not.

Another interesting fact is that the dominant sterols in the insect are 7-dehydro cholesterol and cholesterol. The dietary requirement can be met by a variety of sterols which differ in configuration and degree of saturation.

I don't know where these facts will lead, but they have been revealed by the application of chemistry. Another interesting fact emerged when the entomologist Dr. Frankel working with Dr. Bloch, a chemist, illustrated by means of C^{14}-labelling and isolation by chromatographic methods, that the insect can synthesize the long straight chain hydrocarbon squalene from the 2-carbon unit acetate. The insect is incapable of cyclyzing this hydrocarbon to cholesterol, whereas the mammal can.

It is not certain that these facts are of any practical significance but the idea has occurred to several investigators that reactions involving sterols may be one of the insect's vulnerable spots. Here is something specific that we may use as a "target for control". If we can interfere with the transformation to cholesterol of a sitosterol, which is the sterol a plant feeder consumes, then the insect has received a mortal blow.

It bears repetition that work on sterols with reference to insects has been carried out, by and large, by entomologists. Application has been made of chemical techniques which, in my opinion, are no more difficult to learn than those used to study the non-chemical aspects of insects.

Nutrition of insects is one field that entomologists have investigated with unqualified success. Several centers throughout the world, and Canada is not the least of these, are uncovering facts of great interest. Knowledge of insect

nutrition reveals facets of metabolism which will undoubtedly lead to important discoveries. Nutritionists soon learn to appreciate the importance of pure chemicals and application of chemical techniques, and they have found that in most cases these techniques are not beyond them.

Another fasincating field where physical science is being applied is the physiology of diapause. The nature of the photochemical reaction that influences diapause is still obscure, but as information and knowledge accumulate more specialized people, such as biophysicists, are becoming interested. When they team up with the entomologist it follows as night the day that the nature of the photochemical reaction will be explained. What this could lead to in terms of insect control is obvious. When we know the details of a reaction we may be able to find a means of interfering with it.

A definite association has been shown to exist between diapause and hormonal regulation. It may appear to be a long time before the hormones are isolated and characterized. An intense effort in this field is necessary. This is a case where most likely a chemical mechanism exists that is specific to the insect. Interference with this mechanism, perhaps by means of an antihormone, is not likely to be of any danger to the mammal. Antihormone activity in the mammal is illustrated by the use of antithyroid drugs, such as thiouracil. Obviously thiouracil would not be poisonous to those animals who do not have a thyroid hormone. Similarly interference with a diapausal hormone should not effect vertebrates.

It is of interest to mention some enzyme studies with respect to diapause. Dr. Schneiderman and his co-oworkers applied the information on the biochemistry of respiratory enzymes and found that cytochrome oxidase is the principle terminal oxidase of only the somatic musculature of the diapausing pupa. After the pupal diapause, cytochrome oxidase becomes the terminal oxidase system of the insect as a whole. These changes are the results of hormone action. Studies of this type on insects could reveal the path that biochemical investigation of mammals should follow. The tail then proceeds to wag the dog.

Another important phase of our knowledge of insects is the chemical nature of their fluid and tissues. The difference in chemical composition from stage to stage within an insect, between different species, and the differences between insects and vertebrates constitute a serious gap in our knowldge. These studies can, and do lead to information on metabolism. This type of work requires the skill of the chemical analyst in addition to the knowledge of the entomologist. There has been some excellent work done in this field, and the microchemical techniques required are not easy to learn and perform. One of the many results of this type of study is that furnished by Dr. Wyatt who found that trehalose, a disaccharide, is the principle blood sugar of an insect. This is a significant point with respect to the difference between insects and vetebrates in which glucose is the principal sugar.

No mention has been made of systematics. Here too one finds an attempt by systematists to apply chemistry. They realize that species differences must have a chemical basis and that chemical differences could be as specific as morphological differences. The variation in chemical composition could be, in part, a basis for classification. One example is that of chromatography of insect squashes on paper, with a view to observing differences in the amino acid pattern. This is the beginning of something which could well lead to more detailed studies of great interest and value.

One of the more important metabolic studies that is being carried out is that of detoxication mechanisms, or the metabolism of foreign organic compounds. The surprising observation is the similarity between many insects and mammals in this regard for example, they have similar mechanisms for the formation of hippuric acid and of ethereal sulphates. However, an important detoxication mechanism, formation of B-glucuronides, has not been observed in insects.

Detoxication by dehydrochlorination has aroused most interest because of the importance of D.D.T. It appears that products of detoxication of D.D.T. are different in various species of insects. Resistance to the poison may be due to several factors; one is simply a further development of a normal mechanism and another is development of an alternate detoxication mechanism. It would be redundant to comment on the importance of this branch of entomological chemistry. It is closely related to metabolic investigations in general, and certainly deserves the attention it is getting.

Elucidation of metabolic pathways is an active subject in many laboratories and a description of the enzymatic reactions involved is a most fertile field of study. These lines of investigation follow quite closely the research carried out on higher animals and bacteria. Their importance from an economic point of view is obvious. A knowledge of the metabolic pathways could reveal where we might interfere by means of poison, and suggest poisons that would interfere. The differences in metabolism between insects and vertebrates can furnish a means of pointing up a specific target for attack.

Frequent mention has been made of poisons specific for insects. This leads to the subject of insecticides, and I do not propose to deal with it at great length. There appeared recently a thorough and most valuable compendium of chemical compounds used in crop protection. I refer to the work published by Dr. Martin of Science Service Laboratory at London, in which he lists approximately 900 compounds, many of them insecticides.

This list reflects the intense effort being made in the field of insecticides. It also raises some rather serious problems with respect to poison control. Most of the insecticides are poisonous to vertebrates as well as to insects. It requires a great deal of judgment and cooperation between various agencies to obtain adequate control of these poisons and still retain the greatest measure of crop protection without endangering the health of animals and people who come in contact with the poisons. All problems are not yet solved and every year more arise. This is not just a national problem, since movement of food across borders is quite significant and consumption in Canada of poison deposited in the U.S.A. or Chile is no more palatable nor less injurious, than if it were deposited by a Canadian farmer.

Therefore it becomes clear how necessary it is to find insecticides that are specific for insects and not toxic to vertebrates. A knowledge of comparative physiology and biochemistry is essential to achieve this end. Research in any phase which provides information along this line is fundamental to the problem of insect control.

In closing this address I should like to make reference to our urge to classify. Certainly we cannot do without a complex classification of scientific knowledge. I object, however, to the extent to which we have included scientists in our classification. I abhor the state of affairs where a chemist refuses to consider the whole organism from which his cellular homogenate is obtained, or where the biologist refuses to consider the chemical basis of an animal's behaviour. The

fact is, that much of the chemistry of biological phenomena has been brought to light by scientists who would be classified as biologists. The biologist or entomologist is in a position to make the original chemical observation. It is certain that once the original observation is made there will be plenty of specialists at his door to help him exploit the discovery.

It is my opinion that entomological research needs more than expansion and improvement. There is a definite need to utilize increasingly the research contributions of chemistry, physics, mathematics and atomic energy. Centres for research in entomology do not always have readily available adequate facilities and technical competence in the physical sciences that are becoming increasingly important to entomological research.

Our aim should be to have larger, and consequently of necessity fewer, centers of research whose depth and scope of research are greater. These centers could maintain varied facilities and provide a wide range of professional and scientific skills.

(Accepted for publication: May 22, 1958)

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THE MECHANISM OF EVOLUTION : A SUMMARY[1]

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INTRODUCTION

The gradual unfolding of our living world from simple to complex forms has come to be regarded as organic evolution. This concept was clearly formulated by Jean Baptiste de Lamarck in 1809 in his *Philosophie Zoologique.* Acceptance of this concept, and later the means by which it has come about, have been subjects of wide interest. In the following paper no attempt is made to summarize those broad aspects of evolution which are exemplified by the work of Schmalhausen (34), Simpson (35) and others.

Lamarck believed that a change in environment changed the requirements of organisms and that this led to adaptive changes that were transmitted to the progeny; it was the need for a structure that induced its appearance. Charles Darwin recognized the general inapplicability of this hypothesis but did not refute it in his *On the Origin of Species by Means of Natural Selection* in 1859. He believed that there was a struggle for existence that led to survival of the fittest, and, therefore, that a perpetual process (differential reproduction) favors the evolution of new forms. Darwin called this process natural selection.

In a search for a material substructure that might explain the phenomenon of life, Darwin proposed the pangenesis theory. This theory assumes that particles from all organs of the body are routed through the sexual products, the result of which is the hereditary likeness of offspring to parents. Galton proposed his

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[1]Contribution No. 3761, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada; presented as an invitation paper at the Annual Meeting of the Entomological Society of Ontario, Kingston, October 24, 1957.

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stirp theory in 1854, and Nágeli the idioplasma theory in 1886. However, it was Weismann's theory of the continuity of germ plasm and the localization of his hypothetical hereditary particles (biophores) in 1892 in the chromosomes (discovered by Waldeyer in 1888) that foreshadowed modern genetics. Mendel's paper of 1865 was discovered in 1900 by Hugo DeVries (Holland), Correns (Germany) and Von Tschermak (Austria). Mendel's concept of the segregation and recombination of unit characters was advanced by Boveri and Sutton in 1902, who pointed out the importance of the chromosome mechanism in the hereditary system. The proof of this was provided in 1903 by Johannsen, who showed the difference between environmental effect and particulate inheritance in his studies on beans. Johannsen coined the term *gene*. DeVries' studies on *Oenothera Lamarckiana* Ser. in 1905 gave us the concept of mutation, although as it turned out, DeVries was largely dealing with polyploidy. The demonstration of sex-linked inheritance and the linear order of the genes in *Drosophila melanogaster* Meig. by Morgan, Sturtevant, and others firmly established genetics as a science by 1920. Its importance was greatly enhanced by Muller's discovery in 1927 that x-rays may produce both gene mutations and structural rearrangements of chromosomes; and the further elaboration of this work by Timofeeff-Ressovsky and Stadler.

In the excitement of establishing all of these facts the problem of evolution was not given much attention by geneticists until Fisher in 1930, Wright in 1931, and Haldane in 1932 showed mathematically that small changes in the gene complex are adequate to explain biological evolution in the time (one billion years) since life appeared on this earth. Accordingly, Darwin's concept of favored races came to mean favored genotypes.

CHROMOSOMES

The normal distribution of genes to the gametes occurs in predictable ratios as a result of chromosome movement during the meiotic divisions. When this normal pattern of chromosome distribution is disrupted, variation occurs. In this category we have such chromosomal phenomena as polyploidy and aneuploidy. Any plant or animal that has more than two sets of chromosomes is a polyploid. Polyploidy is a common means of speciation in plants such as *Oenothera* and *Crepis* spp. but this is generally not so in animals. The occurrence of polyploidy is often considered a hindrance to evolution in animals because the spread of new advantageous genes in a population is made virtually impossible by the duplication of so many homologous chromosomes. Aneuploidy, which is the gain or loss of one chomosome of a set, is a common event in somatic tissue but not in the germ plasm. Therefore, aneuploidy is not considered a means of speciation.

Chromosome number may also be altered naturally by centric fusions. These arise by the fusion of two one-armed chromosomes (acrocentric chromosomes) to form one two-armed chromosome (metacentric chromosome). This phenomenon, known as Robertson's Law accounts for many of the species in the genus *Drosophila*. I have discussed this in a recent paper (31). The idea that simple fragmentation of chromosomes leads to an increase in chromosome number is not widely recognized because of the importance of the telomeres (the natural ends of a chromosome) and centromere to chromosome viability (30). White (39) believes that a "donor" chromosome and reciprocal translocation is required. He states that an acrocentric chomosome from which almost all the genetically active material has been removed would seem to be a suitable donor.

Other features of the chromosome complement and therefore the genic constitution are the occurrence of translocations and inversions. Through chromosome breakage, one segment of a chromosome may be transferred to a new position in the chromosome or to a non-homologous chromosome; this is translocation. Inversions occur when one segment of a chromosome is inverted with respect to the same segment in its homologue.

The occurrence of inversions and consequent disruption of the spatial pattern of the genes is a feature of chromosomal polymorphism in *Drosophila* spp. (6,7). All of these chromosomal changes, i.e., polyplody, aneuploidy, centric fusion, translocation and inversion, are known as chromosomal aberrations or, better, as chromosomal mutations.

GENES

One of the fundamental concepts of genes concerns their linear order on the chromosome. According to their effect on the visible features of the organism (the phenotype), genes are recognized as dominant or recessive. Given in one organism a dominant gene, *A,* and in its partner a recessive allele, *a,* fertilization provides the combinations *AA, Aa,* and *aa*. Only the action of the dominant gene, *A,* is observed in the phenotype. Dominant genes usually have favorable survival effects on the organism. In cases of chromosomal deletion, the heterozygote is often unfavorably altered from normal, the dominant genes involved being listed as unfavorable dominants (23).

There are genes that show neither dominance nor recessiveness. These are the genes that govern size, time of maturation, or meristic components of an organism. They are the genes involved in normal variation and usually have simple, additive effects. Their action is associated with quantitative inheritance.

Other classes of genes show compound effects (pleiotropy), control the expression of non-allelic genes (epistasis) or act to produce the effects of quantitative inheritance (polygenes or multiple factors). Some genes (pseudoalleles) appear to act as though they were allelic, and one locus may, alternatively, be the site of a number of genes (multiple alleles). Because more than one gene is required to effect any one character (at least 40 genes are necessary to express wild-type red eye in *D. melanogaster*), the one-gene, one-character hypothesis of Mendelism is not factual. Finally, there is the super-gene, which Darlington (4) recognizes as a block of linked genes acting as a single gene on quantitative inheritance.

Heredity depends on the self-copying attributes of the genes, whereas variation depends largely on the mutabality of genes or new combinations of genes after segregation. Any gene or genes can undergo a change in structure (mutation) and this change is transmitted to the progeny. It has been estimated that 3-10% (7) of *D. melanogaster* in each generation carry a newly arisen mutation. The mutation rate can be increased by ionizing radiation, temperature shock, and certain chemicals, notably the mustard oils. Deleterious mutations that are dominant in effect are eliminated in a few generations, but deleterious mutations that are recessive are sheltered from selection by their normal dominant alleles in heterozygotes. Thus the mass of deleterious recessives carried in normally breeding populations has no disastrous effect on the average fitness of members of the populations. There is no fundamental difference between chromosomal mutations and gene mutations for both lead to sudden changes in the hereditary make-up. Accordingly evolution can be reduced to a study of the dynamics of the gene frequency in a fluctuating environment.

GENE FREQUENCY

In a large, random breeding population with no mutation or selection pressures, no genetic drift and no differential migration, the relative frequencies of each gene allele tend to remain constant from generation to generation. This is demonstrated in the Hardy-Weinburg equilibrium (often called the population equilibrium).

$$q^2\ AA + 2q\ (1\text{-}q)\ Aa + (1q)^2\ aa$$

Here *A* and *a* are adaptively neutral alleles and *q* is their frequency. Thus the familiar Mendelian ration of 1: 2: 1 (25% *AA* alleles, 50% *Aa* alleles, and 25% *aa* alleles) essentially consists of 50% of the dominant allele, *A* and 50% of the recessive allele, *a*. As Jay Lush (26) points out, the science of genetics is the algebra of 1/2.

When the environment changes, or a mutation occurs, the gene frequency may become any value from 0 to 1. Plotting the frequency distribution with *q* values from 0 to 1 along the abscissa and the percentage of heterozygotes (0-50%) along the ordinate, shows that there is not much change in the percentage of heterozygotes *(Aa)* unless the *q* value is extremely high or low. From this it can be concluded that heterozygosity is a salient feature of any population, so that its further consideration in terms of heterosis is essential.

HETEROSIS

The long-held concept of heterosis, or hybrid vigor, is that heterosis is caused by bringing together in the hybrid the dominant favorable genes of both parents. However, more recent research indicates heterosis can be a much more complex phenomenon.

Dobzhansky (8) considers heterosis in two categories, viz., mutational euheterosis and balanced euheterosis. Mutational euheterosis results from the sheltering of deleterious recessive mutants by their adaptively superior dominant alleles in panmictic populations. Here the heterozygote, *Aa,* equals the homozygote, *AA,* in genetic effect. Mutations that are held in a population in this way may be deleterious in the immediate environment (as homozygotes) but advantageous in a new environment; they confer evolutionary opportunism on the population. This is the meaning of the word *preadaptation,* which I used in my recent paper on the resistance of *Macrocentrus ancylivorus* Rohw. to DDT (32).

Balanced euheterosis is due to the occurrence of a rather special class of mutations and gene combinations, which confer on heterozygotes a higher adaptive value than is found in the corresponding homozygotes. Here a heterozygote, *A'á,* may be more viable or more productive or otherwise exceed both homozygotes, *A'A',* and *áá,* in some positive or negative quality. This phenomenon is spoken of as overdominance by Hull (21), as superdominance by Fisher, Immer and Tedin (10), and as dosage heterosis or double dose disadvantage by Huxley (20). The nature of the genic action is not known but Haldane (16) believes that the allele, *A',* may produce its effect at one environmental level (pH, temperature, etc.) and the allele, *á,* the same effect at a slightly different level.

In balanced euheterosis, natural selection preserves in the population all the variants *(A',á)* regardless of how poorly adapted the homozygotes may be. The homozygotes may be lethal and yet selection establishes an equilibrium at which every one of the variants is present in a definite gene frequency. This pheno-

menon of balanced euheterosis is commonly referred to as balanced polymorphism, and may be produced by mutations in single genes provided that the heterozygotes exhibit overdominance in fitness in some environments. Ford (11) and others have shown that in butterflies certain color variants that are inherited as though caused by a change in a single gene are retained in the population by polymorphism. This single gene effect may be strengthened by selection so that a super-gene (p.) is eventually formed (12). White (39) finds in the grasshopper, *Trimerotropis thalassica* Brun., that a high degree of cytological polymorphism is not necessarily adaptive, whereas the absence of such morphism in *T. pallidipennis* Burm. has not hindered its invasion of a large number of habitats. However, detailed data on the adaptive value of balanced polymorphism in natural populations are available for several species of *Drosophila* (9).

Dobzhansky (8) believes the phenomenon to be most compatible with the assumption that overdominance in the heterozygotes is the property not of a single gene locus or of a chromosome structure, but rather of integrated systems of polygenes. Such polygenic systems are coadapted by natural selection to other polygene complexes present in the same population. The work of Jinks (22) and Hayman (17) on *Nicotiana rustica* Linn. shows that overdominance does not fully explain heterosis. Rather it is a composite phenomenon involving the accumulation of favorable dominants, overdominance and epistasis. There is a great deal of work to be done in this important field.

GENETIC HOMEOSTASIS

The idea of coadapted gene systems has recently been emphasized by the concept of genetic homeostasis ("the tendency of a Mendelian population as a whole to retain its genetic composition arrived at by previous evolutionary history") put forward by Lerner (24). Lerner points out that this concept is essentially a genetic projection of the phenomenon of physiological homeostasis (the totality of steady states maintained in an organism through the co-ordination of its complex physiological processes) developed long ago by W. B. Cannon. His mathematical models, which reflect the Hardy-Weinburg equilibrium (p. 25) show the extent that populations resist change under selection. Genetic homeostasis is identical in meaning to Darlington and Mather's genetic inertia (5).

LAMARCKISM

Another aspect of the evolutionary mechanism concerns the possibility of inheritance of acquired characters. This concept is ascribed to Lamarck, who believed that environmental changes created an urgent need in an organism, which then responded by a heritable modification. Today we generally recognize that these changes are of a physiological nature, and therefore reversible in time. Nonetheless, persistent attempts have been made to prove that Lamarckism as such, or in a modified form, is a creative force in evolution.

Waddington (36,38) believes that the mutation theory of evolution is an extreme one. He provides evidence that an initially acquired character (crossveinlessness induced by heat shock of puparia of *D. melanogaster*) is genetically fixed in time. As his explanation involves the possibility of genotypic re-organization of developmental pathways (p. 28), this work is not regarded as Lamarckian.

Crosby (3) believes that a plasmagene (cytoplasmic units of inheritance) system of Lamarckian inheritance may have evolved through natural selection acting on a system of nuclear genes. Plasmagenes are very responsive to the environment, so that any modification from this direction is passed on to the offspring

until natural selection is able to adjust the nuclear system, which is in ultimate control of the plasmagenes. However, a Neo-Darwinian concept is required here and one cannot therefore invoke a Lamarckian explanation until there is proof that cytoplasmic determinants are independent of nuclear control. Moreover, the occurrence of hereditary particles in the cytoplasm as a product of their carrier is open to doubt except for certain plant plastids. Sonneborn's plasmagene, "kappa", may be the chromosomal apparatus of a parasite that has lost its own cytoplasm (25). Other plasmagenes may simply be viruses.

Where Lamarckism is defined as an inherited change brought about by the nonsexual transfer of material from one genetic type to another, Michie (28) points out that scientists in the Moscow Institute of Genetics (under direction of T. D. Lysenko) have made considerable advances. A good example is the case in which a number of blood transfusions from New Hampshire hens to White Leghorn cocks are followed by crossing the treated cocks with a pure line of White Leghorn hens. The resulting chicks, and their progeny, have some plumage characteristics of the donor hen (New Hampshire). It is not clear from Michie's report whether the Lysenko school has profited in recent years by criticisms (18, 29) aimed at their complete disregard for the facts of genetics.

Transformation genetics may also be considered as a nonsexual transfer of hereditary material but the work is linked to desoxyribose nucleic acid (DNA), a chemical known to simulate a gene effect. Recent examples of transformation show that a DNA extract from streptomycin-resistant pneumococci may induce resistance in streptomycin-sensitive bacteria (13) and that when DNA from one strain of ducks is injected into another strain, a somatic modification occurs (15). In the latter case, Greenwood points out that a lack of genetic control makes interpretation of his work difficult. Certainly research in *D. melanogaster* along these lines is indicated.

Cannon (2) has argued on morphological grounds against a purely genetic concept of evolution. In addition, he believes that protoplasm originated before genes and that protoplasm evolved according to the Le Chatelier chemical principle "when a system is in equilibrium, a change in any one of the factors upon which the equilibrium depends will cause the equilibrium to shift in such a way as to diminish the effect of the change". However, chemical enquiries into the origin of life (33) suggest that genes are of a chemical nature, which is consistent with their being recognized as the first form of life, and that their formation and evolution are also consistent with Le Chatelier's principle. It is easy to agree with Sagan that the gene is the precursor of life as no organism devoid of genes is known. By the same token, one can agree with Cannon. Research on viruses may throw further light on this problem. The point that is being introduced, however, is the operation of Le Chatelier's principle and, therefore, the influence of the environment on both the gene and cytoplasm.

CONCLUSION

The outstanding feature of the genetic mechanism is its accommodation of the opposed evolutionary forces of heredity and variation. Heredity promotes preservation of the genotype, whereas variation promotes genetic novelty. Julian Huxley (19) believes that "a single basic mechanism underlies the whole of organic evolution—Darwinian selection acting on the genetic mechanism. . ." and that mutations provide the raw material for this mechanism. Such well-known processes as genetic drift (40), reproductive isolation (27) and introgressive hybridization (1) are essentially genetic, for their effect depends upon changes in the gene frequency.

As the new outlook in genetics is to regard the organism as an integrated genotype, the importance of mutations to evolutionary variation may be overemphasized. Waddington (37) suggests that the natural mutation rate is so low that it will have negligible influence on the overall action of the genotype. In his theory of epigenesis, he visualizes an embryo as a system of developmental pathways, each of which leads to one of the components of the adult. Each pathway is controlled by polygenes that buffer it against minor environmental disturbances. A new pathway may result from selection of existing genes or from a switch gene that affects responsiveness to the environment. Once a new pathway is initiated, however, it becomes stabilized by a system of buffer genes; an evolutionary step has occurred. There is always the possibility that a simple mutation, or the systemic mutation of Goldschmidt (14) (the serial chemical constituents of the chromosomes become arranged in a spatially different order in a series of consecutive steps), may mask experimental evidence in favor of this theory. The correctness of this viewpoint, like that of Waddington's, must await an understanding of the physiology of gene action.

The outstanding difference between Lamarck's theory of evolution and Neo-Darwinian evolution is that the former is purposeful, whereas the latter involves the operation of chance. Beyond this, the two theories have common ground in that a changing environment exerts a force on the organism.

As an organism can be defined as a physico-chemical entity in a physico-chemical environment, there must be times when chemical changes occur that fit the genetic mechanism so that the information gained is transmitted to the progeny. However, if the molecular changes that are caused by the environment do not reach what might be called a mutational threshold, the genetic effect escapes us, and we are in the realm of non-heretitary physiological adaptation. Whether an acquired character reaches genetic status is therefore dependent upon its reaching the mutational threshold.

If we equate an organism under one set of environmental conditions with the chemical equilibrium constant, K, then in new environments, 1, 2, 3. . .n, the organism will become K_1, K_2, K_3 . . . Kn, according to Le Chatelier's principle. These values represent evolution at work. Evolution is a slow process and each pathway to survival is aided by physiological and genetic homeostasis, natural selection ultimately determining the events that have given us our phylogenetic tree. However, it is the environment, and not natural selection, that switches on the genetic mechanism.

SUMMARY

The topic is introduced by giving a brief account of the development of genetics. Sections on chromosomes, genes, gene frequency, heterosis and genetic homeostasis are treated as aspects of the mechanism of evolution, and an account is given of recent work bearing on Lamarckism. The concluding section reconciles the theories of Lamarck and Darwin by emphasizing the importance of the environment to both theories.

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(Accepted for publication 14 May, 1958)

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INSECT VECTORS OF PLANT DISEASES[1]

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There are numerous examples of insects acting as vectors of bacteria, fungi and viruses that cause diseases of plants. Insects may assist pathogens by disseminating them, by helping them infect and invade the host plants; and they may even play a significant role in helping some pathogens to perpetuate themselves. The relations between a vector, a pathogen and a host plant may be very involved; and most associations are unique in at least a few respects.

The following brief review cites a few examples to indicate the range of variation in the role of insects as vectors of plant pathogens.

Bacteria that cause fire blight of apples and pears may be carried from flower to flower on the mouth parts of bees and wasps. Other insects such as flies, ants, aphids and leafhoppers can provide wounds through which fire blight bacteria may gain entrance to tissues of healthy twigs. The striped and twelve spotted cucumber beetles not only carry and infect plants with the bacteria that cause bacterial wilt of curcurbits, but also provide a means of overwintering the bacteria, which are retained in the gut of the insect. The olive knot fly has special anatomical modifications in its intestinal tract which ensure a con-

[1]An abbreviated version of a paper presented at the Annual Meeting of the Entomological Society of Ontario, Kingston, October 25, 1957.

stant culture of the bacteria that cause the olive knot disease. The bacteria are even able to enter the egg and thus ensure perpetuation in the next generation of flies (6).

Conidiophores of the ergot fungus, which is a pathogen of grasses, are disseminated by gnats and other insects that are attracted by the sugary solution in which the spores are suspended. The spores of the brown rot fungus of stone fruits are dispersed by wind, but insects like the plum curculio, which feed on the fruit, provide the necessary infection courts. A more intricate relationship exists between the elm bark beetle and the fungus that causes Dutch elm disease. The bark beetles contaminated with the fungus, feed on tender twigs of vigorous, healthy trees thus inoculating them, then the beetles go to weakened trees where they tunnel, raise a brood, and culture the fungus. When the new brood emerges, the trees that were healthy before they were inoculated by the beetles earlier have become diseased and weakened enough to provide good breeding places for the beetles (6).

The mechanisms of transmission of viruses differ from those of fungi and bacteria because viruses do not produce spores or exudates designed to be blown about by the wind, splashed about by water or tracked about by insects. Viruses occur in plant sap and must enter living cells in order to infect the plant. Few are successfully transmitted by chewing insects that consume most of the tissues contacted by their mouth parts and damage the fringes of the remaining tissues. However, turnip yellow mosaic and potato spindle tuber viruses have been transmitted by chewing insects like grasshoppers, earwigs and beetles. Most plant viruses are transmitted by sucking insects including aphids, leafhoppers, froghoppers, white flies, scale insects and thrips (2, 10, 11, 12). A few are transmitted by eriophyid mites which also feed by sucking (1, 5, 9, 15).

The intricate relations between viruses that cause diseases of plants and the insects that transmit them indicate that transmission can seldom be considered a simple mechanical transfer of virus from diseased to healthy plants. Most viruses are known to be transmitted by only one or a few closely related insect species.

Some virologists group viruses according to their relationships with their vectors as follows: a virus is "non-persistent" if its vector loses its ability to infect within a day after it fed on a diseased plant; it is "persistent" if the vector remains infective more than a day after feeding on a diseased plant (2, 14). The differences between the two types of relationship appear to be set by the virus rather than by the insect. One insect such as *Myzus persicae* may show both relations with different viruses, e.g. non-persistence with potato virus Y, and persistence with potato leaf roll virus.

Vectors of non-persistent viruses may become infective immediately after a short feed on a diseased plant. Often they will transmit better if they are starved for an hour or so before they are given a short feed on the diseased source, then starved again for a few minutes before they are fed on the test plants. It has been suggested that the starving helps transmission of the virus because the starved insects produce less of an inhibitory substance which inactivates the viruses (13). There is evidence that some non-persistent viruses are more abundant in the epidermal cells of the plant, and with short feeds the stylets of aphids penetrate only the epidermis and suck up only the highly infective sap, but if the insects feed longer the stylets penetrate tissues containing less virus, and become filled with less-infective sap, thus the insects transmit less efficiently after long feeds on the source plants (3).

Persistent viruses are considered to have a close biological relationship with their vectors. Many have not been transmitted by manual methods other than grafting, and appear to depend entirely on one or a few closely related species of insects for transmission. The vectors of most persistent viruses remain unable to transmit the viruses for periods that vary, depending on the virus, from a few minutes to several weeks after they have first fed on the virus source (2). After this latent period they may be able to transmit for an extended period of time. The latent period may represent the time required for the virus to undergo a developmental change, or as suggested by results of work with the corn streak virus transmitted by *Cicadulina mbila,* it may represent the time required for the virus to penetrate the gut wall, enter the blood stream and pass into the saliva. There is now good evidence that in some instances the latent period actually represents an incubation period during which the virus multiplies in the vector. It has been proved by serial passage of dilutions of body juices from one insect to another, that aster yellows virus, wound tumor virus and corn stunt virus multiply in the leafhoppers that transmit them to plants (7). Aster yellows virus even multiplies in cultures of tissues from the insect's body (8). The viruses that cause rice stunt disease, clover club leaf, wound tumor, rice streak, and European wheat striate mosaic can be transmitted by the infective female Cicadellid vectors through the eggs to the next generation. Clover club leaf virus was passed through the eggs of 21 successive generations of leafhoppers that were not given an opportunity to acquire virus by feeding on diseased plants. Thus it appears that some viruses can multiply in the insect as well as in plants.

It is important to understand the relations between a particular virus and its vector when attempting to control the virus by means of insecticides. Insects that can transmit a virus will not spread the virus unless they move from plant to plant. Therefore, the objective for controlling the virus is not necessarily to reduce the number of insects but to prevent infective insects from moving either into a susceptible crop or from plant to plant within the crop, or at least to prevent them from infecting the plants. If an insecticide is applied on the crop, it must be quick acting if it is to control non-persistent viruses which can be acquired and transmitted by their vectors during short feeds. An insecticide that irritates but kills slowly may cause the insect to move frequently and infect more plants before it finally dies than it would have infected if no insecticide had been applied. Persistent viruses that are acquired and transmitted slowly by the vector can sometimes be controlled even by slow-acting insecticides applied on the crop (4).

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(Accepted for publication: 7 May, 1958)

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II. SUBMITTED PAPERS

EFFECTIVENESS OF TWO INTRODUCED PARASITES OF THE LARCH CASEBEARER, COLEOPHORA LARICELLA (HBN.) (LEPIDOPTERA: COLEOPHORIDAE), IN ONTARIO[1]

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A previous paper (1) dealt with the importation and release of five species of parasites of the larch casebearer, *Coleophora laricella* (Hbn.), and gave a preliminary assessment of their establishment and effectiveness in Ontario. In 1949 (2), establishment of two of the parasite species, *Chrysocharis laricinellae* (Ratz.) and *Agathis pumilus* (Ratz.), was confirmed; the former was found up to 36 miles from the point of liberation and the latter up to 135 miles. At that time the larch casebearer infestation was decreasing in Ontario, and was extremely light in the area in which the two species of parasites were established.

This paper substantiates the assessment made in 1949, and reveals new evidence of the value of the parasites in the control of this casebearer.

METHODS

Data were obtained by collecting the distal 12 inches of branches of infested larch at approximately breast height on four sides of a tree. The cases were removed from the twigs in the laboratory and placed in a commercial solution of sodium hypochlorite to dissolve the silk. The host larvae were dissected under water with the aid of a dissecting microscope. When possible, 100 cases from each collection point were dissected.

Collections were made by the author in April and early May, 1957, before the casebearers began feeding. Forest insect rangers of the Forest Biology Division, Canada Department of Agriculture made additional collections throughout May, after feeding had begun.

A total of 56 collections were made ranging from Batchawana, 30 miles north of Sault Ste. Marie, to Mattawa, in the north, and from St. Thomas to Smith's Falls in the south. This area extends over six degrees of longitude and four and one half degrees of latitude and comprises more than 65,000 square miles.

RESULTS AND DISCUSSION

A. pumilis was found at all points where collections were made: *C. laricinellae* was not found beyond 42 miles from the points of release (Fig. 1 and Table I).

Fig. 2 shows that the average parasitism by *A. pumilus* increased from 41 per cent south of 43° to 67 per cent between 44° and 45°, and then decreased sharply to 15 per cent north of 46°. Mortality of the casebearer from all other factors during the winter increased from south to north averaging approximately from two per cent south of 43° to 32 per cent north of 46°. The increased winter mortality of the casebearer compensated for the decreased parasitism by *A. pumilus* in the northern part of the survey area.

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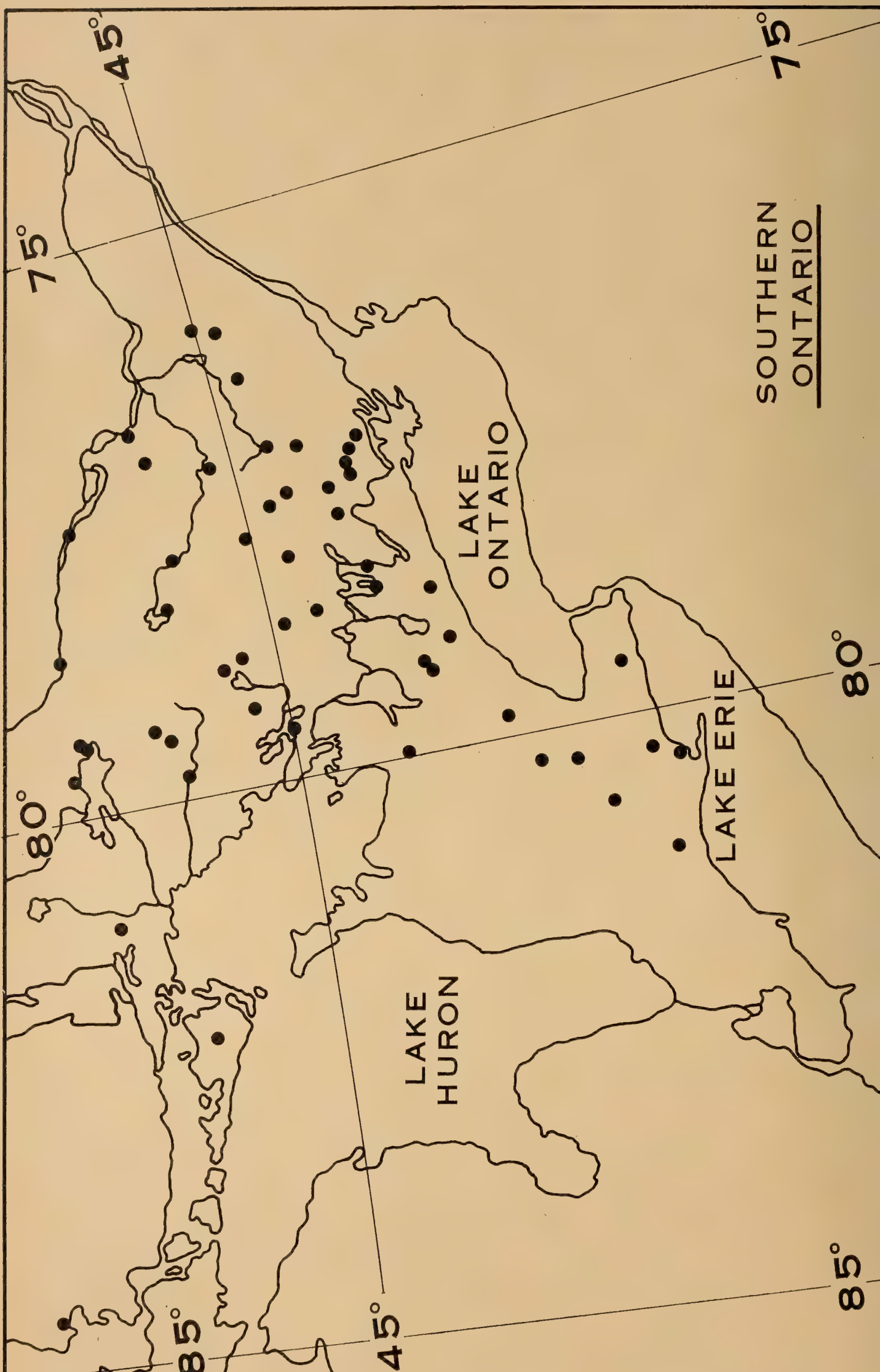

Fig. 1. A map of southern Ontario showing the points where the larch casebearer was collected.

Table I

Percentages of the larch casebearer parasitized by *A. pumilus and C. laricinellae* at various collection points in southern Ontario, 1957

Collection point	Latitude north	Number of host larvae dissected	Percentage unparasitized host larvae Living	Dead	Percentage parasitized by A. pumilus Living	Dead	C. laricinellae Living	Dead
Batchawana, Fisher Twp.[a]	46°-45'	100	11.0	16.0	35.0	7.0	0.0	0.0
Beaucage	46°-20'	100	33.0	62.5	4.5	0.0	0.0	0.0
North Bay, 5 mi. E.	46°-15'	80	10.0	38.75	7.5	43.75	0.0	0.0
Mattawa, 3 mi. S.	46°-15'	100	41.0	15.0	38.0	6.0	0.0	0.0
North Bay, 5 mi. S.	46°-12'	100	65.0	29.0	6.0	0.0	0.0	0.0
Secord Twp. L. 3 C. VI-[b]	46°- '	7	42.8	0.0	57.2	0.0	0.0	0.0
Deep River	46°-05'	69	39.0	11.8	33.9	15.3	0.0	0.0
Sundridge, 4 mi. N.	45°-41'	100	66.0	10.0	24.0	0.0	0.0	0.0
Manitoulin Is. Bidwell Twp.-[b]	45°- '	21	85.7	0.0	9.8	4.5	0.0	0.0
Sundridge, 5 mi. W.	45°-37'	86	44.2	9.3	46.5	0.0	0.0	0.0
Ahmic Harbour	45°-34'	59	39.15	26.0	30.45	4.4	0.0	0.0
Algonquin Pk., E. gate	45°-30'	66	27.27	10.66	48.42	13.65	0.0	0.0
Cobden	45°-29'	50	42.0	18.0	24.0	16.0	0.0	0.0
Eganville	45°-26'	64	18.75	4.69	75.0	1.56	0.0	0.0
Madawaska	45°-25'	21	24.0	8.0	60.0	8.0	0.0	0.0
Parry Sound, 8 mi. N.	45°-22'	100	47.0	24.0	29.0	0.0	0.0	0.0
Dwight	45°-17'	41	48.8	0.0	48.8	2.4	0.0	0.0
Stephenson Twp. Con. IV	45°- '	100	31.0	2.0	63.0	0.0	0.0	0.0
Kushog Lake	45°-07'	100	9.0	0.0	85.0	6.0	0.0	0.0
Denbigh	45°-05'	100	28.0	2.0	64.0	6.0	0.0	0.0
Bancroft	45°-01'	100	27.0	2.0	65.0	6.0	0.0	0.0
Franktown	45°-01'	60	16.6	5.0	63.3	15.1	0.0	0.0
Torrance, 3 mi. S.	45°-00'	70	38.57	12.85	48.58	0.0	0.0	0.0
Minden	44°-57'	100	18.0	2.0	75.0	5.0	0.0	0.0
Port Elmsley	44°-56'	100	7.0	1.0	85.0	7.0	0.0	0.0
Maberly	44°-51'	100	11.0	4.0	63.0	22.0	0.0	0.0
Steenburg	44°-51'	68	15.5	12.0	46.75	13.75	12.0	0.0
Apsley	44°-48'	100	37.0	2.0	59.0	1.0	1.0	0.0
Northbrook	44°-47'	100	12.0	6.0	49.0	12.0	0.0	21.0
Millbridge	44°-45'	100	8.0	2.0	55.0	10.0	25.0	0.0
Kaladar, 8 mi. W.	44°-36'	100	16.0	6.0	71.0	7.0	0.0	0.0
Marmora	44°-26'	100	7.0	4.0	89.0	0.0	0.0	0.0
Havelock	44°-25'	100	5.0	4.0	91.0	0.0	0.0	0.0
Cameron	44°-25'	100	27.0	8.0	65.0	0.0	0.0	0.0
Peterborough	44°-20'	100	8.0	6.0	84.0	1.0	1.0	0.0
Omemee	44°-18'	100	10.0	6.0	84.0	0.0	0.0	0.0
Camp Borden	44°-18'	100	38.0	24.0	38.0	0.0	0.0	0.0
Holloway	44°-18'	100	7.0	4.0	89.0	0.0	0.0	0.0
Stirling	44°-18'	100	17.0	10.0	73.0	0.0	0.0	0.0
Kinmount, Somerville Twp.-[b]	44°-17'	100	14.0	0.0	86.0	0.0	0.0	0.0
Plainfield	44°-17'	100	34.0	4.0	62.0	0.0	0.0	0.0
Melrose	44°-15'	100	18.0	4.0	78.0	0.0	0.0	0.0
Uxbridge Forest	44°- '	62	14.5	0.0	85.0	0.0	0.0	0.0
Bewdley	44°-06'	100	12.0	0.0	86.0	2.0	0.0	0.0
Vivian Forest-[b]	44°- '	36	36.1	0.0	63.9	0.0	0.0	0.0
Orono-[c]	43°-59'	100	27.0	11.0	60.0	0.0	0.0	0.0
Greenwood	43°-55'	100	60.0	15.0	25.0	0.0	0.0	0.0

Collection point	Latitude north	Number of host larvae dissected	Percentage unparasitized host larvae Living	Dead	Percentage parasitized by A. pumilus Living	Dead	C. laricinellae Living	Dead
Georgetown	43°-42'	100	5.0	56.0	39.0	0.0	0.0	0.0
Guelph, 3 mi. S.	43°-31'	85	22.5	1.1	76.4	0.0	0.0	0.0
Galt, 5 mi. S.	43°-18'	100	20.0	9.0	70.0	0.0	1.0	0.0
Woodstock, 2 mi. E.-[b]	43°- '	80	25.0	0.0	75.0	0.0	0.0	0.0
Dunnville-[b]	42°- '	18	66.66	0.0	33.34	0.0	0.0	0.0
Simcoe, 3 mi. W.	42°-50'	69	23.2	2.9	73.9	0.0	0.0	0.0
St. Thomas-[b]	42°- '	40	12.5	0.0	87.5	0.0	0.0	0.0
St. Williams	42°-40'	100	22.0	4.0	74.0	0.0	0.0	0.0
Wild Goose, MacGregor Twp.-[b], [d]	48°-29'	100	98.0	1.0	0.0	0.0	0.0	0.0
Average		81.1	28.37	9.22	56.43	4.22	6.67	3.5

[a]-Twenty-nine chalcidoids and two unknown braconids (31.0%).

[b]-Collections made too late for winter mortality data.

[c]-Two unknown chalcidoids (2.0%).

[d]-One unknown chalcidoid (1.0%).

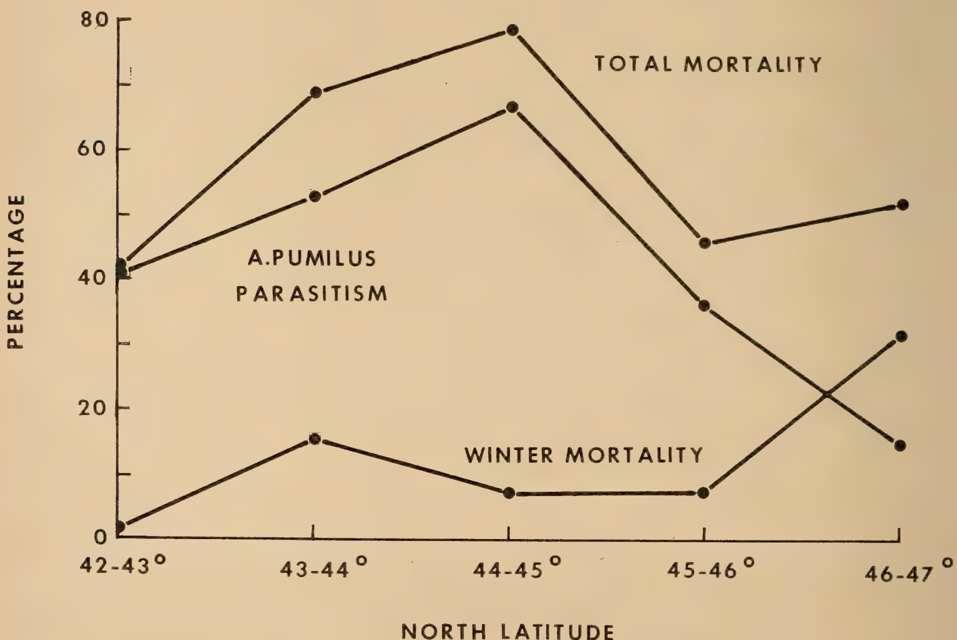

Fig. 2. Total mortality, percentage parasitism by *A. pumilus* and mortality of the larch casebearer from other factors during the winter.

The larch casebearer infestation was very light over the area surveyed except for a medium infestation at St. Williams, Norfolk County. In some parts of the area no infestation was found. Although the infestation was light and the

larch stands discontinuous, *A. pumilus* has evidently become established throughout southern Ontario.

The parasites were released from 1935 to 1941 at four points in southern Ontario: Ottawa, Kemptville, Millbridge and St. Williams. *A. pumilus* may have spread entirely from these points of release. However, it is more likely that *A. pumilus* reached the extreme northwest of the survey area from a colony that was released in Iron County, Michigan, in 1951. Referring to this colony, Professor S. A. Graham, University of Michigan, Ann Arbor, Michigan stated (in litt): "By 1953, it had spread eastward over 60 miles and was very effective in the area". The high percentage parasitism by *A. pumilus* at Batchawana, contrasted with the low percentage on Manitoulin Island, the next most westerly point of recovery, may indicate a spread from Michigan into Ontario aided by prevailing westerly winds.

A. pumilus is the most effective biological control agent operating against the casebearer in Ontario. It has spread over a large area with light discontinuous infestations of the casebearer and parasitized rather large percentages of the populations.

C. laricinellae is not an effective biological control agent. It has spread a maximum of 42 miles since its release in 1934. The ability of *C. laricinellae* to spread depends on high host populations (2) and is thus in contrast with the action of *A. pumilus.*

Some effects of predation by birds on the overwintering casebearers were noted in the collections. There were indications of two flyways used by nuthatches, creepers, wrens, warblers, and other species during migration: one in the valley of the Ottawa River and the other along the east coast of Georgian Bay. In these areas there was evidence of up to 21 per cent destruction of the overwintering casebearers by birds.

SUMMARY

A. pumilus is the most effective introduced parasite of the larch casebearer in Ontario south of Lake Superior.

C. laricinellae, however, has not been proved to be effective as a control of the casebearer.

Predation by birds during migration in flyway areas destroyed up to 21 per cent of the overwintering casebearers.

ACKNOWLEDGMENTS

I wish to thank Dr. R. M. Belyea, Officer-in-Charge, Forest Insect Laboratory, Sault Ste. Marie, Ontario, and the many forest insect rangers who collected and forwarded material for use in this study.

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(Accepted for publication: 14 May, 1958)

NOTES ON METHODS FOR REARING TWO CANADIAN FOREST INSECTS[1]

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One of the problems facing investigators of Canadian forest insects is that the insects are usually available for only a few months in each year. Rearing the insects in the laboratory has proved very difficult in many cases. Experiments have been conducted at Sault Ste. Marie with two Canadian forest insects and rearing methods proved sufficiently successful to warrant a report at this time.

The first insect investigated was the larch sawfly, *Pristiphora erichsonii* (Htg.). The original rearing stock was supplied and cared for by the Forest Insect Laboratory. Collections of cocoons were from the current or the past year's populations.

Collections were divided into lots of twenty-five and were placed in 8 oz. glass jelly jars with vermiculite moistened with 10% aqueous solution of Mycoban (sodium propionate.). The jars were provided with screened tops and were held at room temperature (70-72°F., and 65% R.H.) until mid-October when they were transferred to storage in a temperature-controlled room. While held at room temperature the jars were watered once every two weeks, with the final moistening just before going into storage. The temperature was lowered at the rate of 2°F. per day to about 34°F. (R.H. approximately 85%). Cocoons were kept under these conditions till mid-January when temperature increases of 2°F. per day commenced. Cocoons were brought out on February 1st and held at room temperature until eclosion took place. The adults were supplied to the writer as soon as they emerged.

There were two major difficulties involved in rearing consecutive generations of the larch sawfly.

(a) A constant supply of larch foliage had to be obtained during the winter months in order to feed the larvae.

(b) The insect lays its eggs only in the new shoot of the plant and apparently requires a shoot at least 2.5 cm. long to allow good oviposition. Previous attempts to obtain shoots from larch trees in the greenhouse had not been successful.

The first problem was easily solved by collecting larch foliage in the fall and preserving it in a freezer locker. The foliage was collected in August when the leaves were full grown. Leaf fascicles were stripped from the branches, soaked in 0.1% Mycoban for 5 min., dried for 10 min., on paper towelling, packed in cellophane bags and frozen at 14°F. Foliage was removed from the freezer and allowed to warm to room temperature before larvae were placed on it.

The second problem was finally overcome when Vaartaja (1957) published his work on photoperiodic responses in seedlings of northern tree species. Using a modification of Vaartaja's method, larch saplings (six feet in height) brought into the greenhouse at the beginning of January, received extra light from sunset to 10 p.m. and from midnight to 1 a.m. every night.* This induced production of shoots, which reached the required length of 2.5 cm. in about 30 days.

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[1]Contribution No. 456, Division of Forest Biology, Science Service, Department of Agriculture, Ottawa, Canada.

*Illumination was provided by two banks of fluorescent lights, each 96 in. long, and containing eight 80-watt tubes (Westinghouse 96T8). The lights were hung seven feet from the floor.

Freshly emerged females were placed in fine-mesh, nylon-tulle sleeves, which were tied over the shoots. The insects began ovipositing almost immediately. Larval hatch began 12 to 14 days after placing the females on the shoots. These larvae were reared through the larval stage in petri plates containing larch foliage which had been preserved by freezing. Foliage was changed every three days.

The second insect dealt with was the forest tent caterpillar, *Malacosoma disstria* Hbn. In this case the purpose was to supply larvae for experiments from December till May. Although adults were readily obtained, no attempt was made to mate them.

The main difficulty in rearing young tent caterpillar larvae out of season is to supply them with food of the proper age and condition. Sippell (1952) described a method of rearing this insect on a combination of oak seedlings and forced poplar leaves, but he pointed out that the germination and growth of the seedlings must be closely synchronized with the hatching of the insect, a task that proved difficult and time consuming. The following method required much less effort and care, while yielding healthy larvae.

Egg bands were collected and kept at 32°F. until early December. The bands were then brought to room temperature and were moistened twice daily while lying on filter paper in petri dishes. When hatching occurred (in two to six days) a leaf of head lettuce was placed in each petri dish. Larvae successfully passed through two instars on this food but died when they reached third instar, if they were not changed to a natural host plant within 48 hours. The second instar larvae were transferred to sprigs of pin cherry set up in lantern globe rearing jars. These larvae established readily on cherry leaves two to five weeks old, thus eliminating the need for closely timing the development of the host plant.

To supply the pin cherry foliage, saplings were transferred to butter boxes in September and were held outdoors until November when they were moved into the greenhouse and kept at a temperature of 65-70°F. Artificial light was provided from sunset until 10 p.m. each day, the lighting units being the same as used for the larch. Approximately one month after the plants were brought into the greenhouse, leaves had grown to a suitable size for young larvae to feed on. Families from each egg band were reared separately, and any diseased families were destroyed. This is a very important precaution since the supply of eggs is always drawn from the field and introduction of diseased larval clutches is a constant threat to healthy rearings.

ACKNOWLEDGEMENTS

I should like to take this opportunity to thank Dr. W. L. Sippell, and his staff of the Forest Insect Survey, Sault Ste. Marie, for supplying insects and for much of the information regarding the method for obtaining viable larch sawfly adults.

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(*Accepted for publication on 14 May, 1958*)

THE TARNISHED PLANT BUG, LIOCORIS LINEOLARIS (BEAUV.) (HEMIPTERA: MIRIDAE), AS A PEST OF PEACH IN ONTARIO: A PROGRESS REPORT[1]

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For many years peach growers of the Niagara district of Ontario have suffered losses from a gummy scarring of the fruit that either rendered it unsalable or lowered its grade. Losses have varied greatly from year to year, but severe injury has usually been restricted to a very few orchards. In 1956, however, the injury was severe throughout the area, ranging from a trace to 40 per cent, with an average of 17 per cent.

This type of injury had long been confused with the very similar injury caused by the oak and hickory plant bugs, *Neolygus* spp. However, exceptionally widespread injury in 1937 indicated that some other insect was involved. The tarnished plant bug, *Liocoris lineolaris* (Beauv.) (*Lygus lineolaris* (Beauv.)), was suspected because tests conducted at the Vineland Station laboratory in that year showed that it was capable of causing the type of scarring that had been seen in the peach orchards. Porter (7) and Porter *et al.,* (8) had shown previously that the tarnished plant bug was responsible for an injury to peach in Illinois that resulted in a severe distortion of the fruit known as cat-facing. This type of injury also occurs in Ontario peach orchards, but it is not of great economic importance. Of the five types of injury described by Rings (9), four (fruit drop, cat-facing, scarring, and gummosis) may result from tarnished plant bug feeding on the fruit, but only scarring and gummosis are important in Ontario.

Work in Illinois (1, 2) and Virginia (11) indicated that sprays of DDT, dieldrin, BHC, or parathion applied during and shortly after the bloom period gave good control of the tarnished plant bug. However, in the heavy infestation year of 1956 in Ontario the few growers who applied DDT at or near the bloom period got no control. Similar failures were reported in New York State by Dr. E. H. Smith (in litt.), New York State Agricultural Experiment Station, Geneva, N.Y. This suggested that immediately after bloom was not the time when the important injury occurred in the Niagara area of Ontario and adjacent New York State, and that the habits of the bug in this area may be different from those reported in more southern regions.

Crosby and Leonard (3), in apparently the first comprehensive study of the tarnished plant bug, established that in New York State it overwintered in the adult stage and emerged in the spring about the time that tree buds were opening. Porter (7, 8), Woodside (10, 11), and Chandler (1, 2) found that the adults were most numerous in peach orchards from the time of bud-burst to petal-fall; after full bloom the population fell off rapidly and very few were observed as late as the shuck-split stage. The only report that the bug may attack peach fruit after the period immediately following bloom is by Lowe (4), who found it feeding on peaches in June and causing them to exude gum.

Although the bug has been reported by a number of authors as feeding and breeding on a great many host plants, its relation to its various hosts does not appear to have been clearly established. Painter (5) showed that the overwintered adults oviposited on different hosts from those of the adults of the first genera-

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[1]Contribution No. 3749, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada; presented to the 94th annual meeting of the Society at Kingston, Ontario, October, 1957.

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tion. Woodside (11) stated that the adults preferred plants just coming into bloom, and therefore bred on a succession of different hosts throughout the season; he did not correlate the hosts with the different generations. These observations indicate a periodic movement of the bug from one host to another and it was thought that this might explain the occurrence of the adults on peach, a host on which they do not normally breed. Therefore, the investigation reported herein was begun in the spring of 1957 to determine the habits of the bug in the Niagara district and to attempt to correlate them with the injury on peach. Some preliminary control experiments based on this information were also undertaken.

SEASONAL HISTORY AND HOST PREFERENCES

Observations over many years made in connection with other peach orchard studies by members of the staff of the Vineland Station laboratory have indicated that very few tarnished plant bugs are present in peach trees after petal-fall, although some might be present at any time during the growing season and they often became abundant on the cover crop, particularly toward the end of the season.

During the present study the occurrence and relative abundance of the bug were determined by sweeping orchard headlands, pastures, hay fields, roadsides, the verge of woodlands, and orchard cover crops with an insect net, and by jarring trees in selected peach orchards. From the first warm weather in early April, sweepings were made almost daily up to the appearance of the first-generation adults and at irregular intervals thereafter to the end of October. Both the sweeping and jarring collections showed that the overwintered adults were relatively scarce and only a few were taken from peach trees during the bloom period. They were found consistently, although in small numbers, only on red clover, alsike, and alfalfa. First-generation nymphs were collected only from clovers and alfalfa and extensive searching indicated that in 1957 these were the only important hosts of the spring generation. Nymphs appeared to be present on clover wherever it occurred, even on isolated plants along roadsides.

First-generation adults began to emerge about June 12, the peak emergence being between June 15 and 20. This was about the same time that clover was being mowed for hay. There was a definite movement of the adults from clover, hastened by mowing. However, collections in peach orchards during this period did not indicate an upward surge in numbers, although a few were present on the trees. By the middle of July only an occasional specimen was swept from clover and no second-generation nymphs were found on this host.

A second generation built up rapidly on a species of *Erigeron* that bloomed in early July. Eggs were found inserted among the disk florets and appeared to have been laid just before the flowers opened. Often one or two, but as many as five or six, eggs were laid in each flower. Eggs were found in much smaller numbers in the flower heads of oxeye daisy, *Chrysanthemum leucanthemum* L., and of *Anthemis cotula* L.; and in the stems of common ragweed, *Ambrosia artemisiifolia* L. Although *Erigeron* sp. was the preferred host at this time of year, it was scarce in many localities and might have contributed fewer to the total of the second generation than some less-favoured but more numerous hosts.

The first adults of the second generation began to appear on *Erigeron* sp. about July 30. Because the plants were senescent, the period over which the bugs matured on this host was short, but a large number of adults was produced. First-generation adults were still present in the field at this time and second-

generation nymphs were numerous on several common weeds. Because of this overlapping of the broods the generation of any of the subsequent populations on the various hosts was not determined. There was good reason to consider, however, that at least three generations were produced during the season. Collections during August and September showed that nymphs were present on a large number of weed hosts, the more important of which were ragweed, pigweed, *Amaranthus retroflexus* L., lamb's quarters, *Chenopodium album* L., and common plantain, *Plantago major* L. There was little indication of any preference for a particular host until September when nymphs and adults became very numerous on *Erigeron canadensis* L. and *Aster* spp. As late as October 29 large numbers of adults were present on weeds that still remained green in the field. The numbers in clover and alfalfa fields at this time were very low.

Attempts to rear the bug in cages were largely unsuccessful. Only sufficient were reared to indicate that at least three generations could complete their development before the end of September. Mortality of first- and second-instar nymphs was high, and adults laid only a small number of eggs, many of which failed to hatch.

FRUIT INJURY

To correlate the type of injury at harvest with the stage of development of the fruit at the time the injury took place, 40 branches of Elberta peach each bearing not fewer than 10 blooms were caged singly in wire-mesh sleeve cages just as the petals were beginning to fall. On the third day after petal-fall, four tarnished plant bug adults collected from clover were placed in each of four of the sleeve cages, and this procedure was repeated every fourth day to the thirty-first day after petal-fall. The bugs were removed after 48 hours and the fruit was kept caged until two weeks before harvest, or a total of 110 days.

The feeding injury on young fruits, up to three weeks after petal-fall, was detectable within 24 hours after the bugs were placed in the cages. The injury was similar to that described by Porter (7) and appeared first as a water-soaked area over which the pubescence was somewhat darker in appearance. Under this area the tissues were soft and pulpy and within a day or two they turned brown and collapsed, leaving a cavity under the epidermis. Later the epidermis over the injured area dried up and broke away, exposing the cavity in the fruit. Most of the fruit injured up to the seventeenth day after petal-fall dropped, but some that were only slightly injured continued to develop. Fruit injured up to the twenty-first day after petal-fall, if it remained on the tree, developed the deep depressions and distortion of cat-facing. Fruit injured from the twenty-first to the thirty-third day showed progressively less distortion and injury was more of the scarring or gummosis type, depending on the extent of the feeding. Gummosis appeared to be characteristic of later injury, but gum was sometimes exuded by peaches injured only six days after petal-fall. Peaches usually exuded gum within a few hours of being injured and some continued to do so for several weeks.

Random collections of 200 peaches from each of 19 orchards on June 13 indicated that the average injury by the bug at that time was less than 0.5 per cent and the maximum injury in any orchard was 2 per cent. A second sample of 100 peaches per orchard on July 3 showed that the average injury had increased to 9 per cent, with a maximum in one orchard of 21 per cent. Less than 1 per cent of this injury was of the cat-facing type. Records based on 11-quart samples from a smaller number of orchards at harvest in late August

and September showed an average injury of approximately 5 per cent, indicating that there was no further injury after early July.

CONTROL

Spray tests were carried out in two peach orchards, but up to the time of the appearance of first-generation adults injury in both orchards was so slight that any effect that the sprays may have had was not detectable. However, when it was realized that first-generation adults were dispersing from alfalfa and clover, a special spray of 50 per cent DDT wettable powder at 2 lb. per 100 gal. was applied on June 17 to four plots in one of the experimental orchards that had less than 1 per cent injury. A sample of 100 peaches taken from each plot on July 4 showed average injury of 4 per cent in the four sprayed plots and 10 per cent in the two unsprayed plots.

DISCUSSION

These preliminary investigations, linked with the observations and experience of several workers in the area over a number of years, suggest that in the Niagara district the adults of the overwintered generation of the tarnished plant bug cause only a negligible amount of injury in the peach orchards. Even if they were numerous in the orchards during or shortly after the bloom period, nearly all of the fruit injured at this stage would evidently drop soon afterwards. In a year when fruit set is poor and the tarnished plant bug population is high, this might result in a serious reduction of the crop, but such a situation has never been demonstrated and the setting of too many fruits is a more usual problem with peaches than the setting of too few.

The sampling of populations indicated a distinct dispersal of the first-generation adults from the spring host. This movement occurred when almost all of the injury that was apparent at harvest occurred on peach. Dispersal of the adults of later generation from their hosts was not so distinct, and if it took place appeared to have no effect on the amount of injury. It is possible, however, that a movement of a large number of adults may occur later in the season in a particular area where a favourable host of the second generation is abundant, and that under these conditions the injury to peach fruit may occur later than was indicated during 1957.

The controlled feeding tests further supported the view that most of the injury was caused by first-generation adults. Most of the injury was of the scarred or gummosis types, which these tests indicated were the types produced by bug attack during the time that this generation was maturing. The orchard sampling also indicated that almost all of the injury took place during this time. The lower incidence of injury at harvest than in early July probably resulted from the removal of the more seriously injured fruit either through natural drop or in the thinning process.

The results of the spray tests were inconclusive. Although the amount of injury in one orchard was reduced by 50 per cent by a single spray of DDT applied when the first generation adults were moving from alfalfa and clover, it still remains to be determined whether economical commercial control can be obtained with DDT or more effective materials at this period.

SUMMARY

The tarnished plant bug, *Liocoris lineoloris* (Beauv.), has caused a gummy scarring of peach fruit in the Niagara district of Ontario for many years.

Investigations in 1957 established that the first generation of the bug occurred almost exclusively on red clover, alsike, and alfalfa. Adults of this generation dispersed to various other hosts from mid-June to early July. Nearly all of the injury on peach, that was visible at harvest, occurred during this period. Controlled feeding tests showed that bugs feeding on the developing fruit at the time that first generation adults were maturing produced injury similar to the scarring most commonly seen in the peach orchards. In preliminary control experiments DDT applied when first-generation adults were beginning to disperse reduced injury by approximately 50 per cent.

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(*Accepted for publication*: *May 22, 1958*)

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A REVIEW OF ENTOMOLOGICAL ACTIVITIES OF PLANT PROTECTION OFFICERS IN TORONTO[1]

The Staff

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Work of a Plant Protection Officer is varied, covering as it does the supervision of imports and exports of nursery stock and plant products to prevent

[1]Plant Protection Division Contribution No. 124.

[2]Cyril Copeland, Officer-in-charge.

the introduction of new or serious pests and to comply with restrictions placed by other countries. In addition, enquiries, which we endeavour to answer, are received from numerous sources regarding the identification and control of various pests. Projects are conducted to prevent the entry of insect pests not yet established or to control those that have gained entry, before they spread. Surveys are made. Fumigaions are supervised to comply with import regulations and with those of foreign countries receiving Canadian material. This work is of necessity general, and officers must depend on other more specialized scientific officers for advice and information at times. Much progress has been made with the identification of specimens submitted to headquarters, and with the increase in number of systematic and economic entomologists we are usually able to secure prompt and definite identifications and dependable information regarding control. This was impossible when staff was much smaller, and often we were unable to get identifications beyond the order of the insect. Better identification has been of great assistance to our own officers in familiarizing themselves with injurious insect pests and has enabled them to render a greater service to the public as a whole. The same applies to other disease-producing organisms of plants. We are therefore confining our remarks to those phases of our entomological activities that we believe will be of most interest to this group.

Our work with stored-product insects has been quite extensive. Shippers loading cereal and cereal products for overseas or for storage are compelled to comply with regulations of the Destructive Insect and Pest Act regarding freedom from insects. To accomplish this it may be necessary to spray or, at times, fumigate. Imports of nuts, copra, and other products are checked for stored product insects. In addition to the above, many countries require certificates of freedom from pests in cereal or cereal products, which are usually issued by our officers, based on a satisfactory standard of cleanliness in the mills and warehouses. As a result, we find ourselves checking ships, mills and warehouses for insects regarded as serious pests of stored products. We have also co-operated with stored-product insect officers in the solution of problems of insects infestation in elevators, mills, warehouses etc. Insects dealt with in the work are almost universally distributed and are generally known, so that no mention of the specific pests will be made here except to note that officers are continually on the lookout for new, as well as the universally distributed, pests.

Foreign insects well known for their damage are frequently intercepted during import inspections. Among these might be mentioned gypsy moth, *Porthetria dispar* (L.); brown-tail moth, *Nygmia phaeorrhoea* (Donov); dura stem borer, *Sesamia cretica* (Led.), a serious pest of products such as broom corn; leopard moth, *Zeurzera pyrina* (L.) a pest intercepted in Malus; European leaf beetle, *Pyrrhalta viburni* (Payk), not known to occur in North America but intercepted twice on *Viburnum* at Toronto during the past few years. Many others which may or may not be established have been encountered; among these *Anobium punctatum* Deg., a powder post beetle, is probably worthy of mention. This was found in settlers effects (furniture) imported from Holland. Various pieces were punctured many times with the burrowings of this insect. Fumigation was necessary to prevent further distribution. Various injurious nematodes are also being encountered from time to time.

Japanese beetle – *Popillia japonica* Newm. is another insect with which we have had contact for a number of years. The first living beetle in Canada was found in a car at Yarmouth, Nova Scotia in July 1936. The first infestation was discovered in Canada in 1940 at Queen Victoria Park, Niagara Falls, a second establishment in Windsor in 1941. More than seventy acres were treated with arsenate of lead in these two infested areas. Since 1941, beetles have been

found in various places with 14 found in Hamilton in 1942. Since that time fluctuations have taken place in Hamilton with a peak of 430 beetles in 1946, and of 403 in 1956. The lows for this period were nine in 1943 and ten in 1947. During the 15 year period 1,995 beetles were collected in that city. In each case, a marked decrease occurred after soil treatment, although weather may have been a contributing factor. Beetles found in other locations, such as the Toronto area, have not persisted, either as a result of treatment or unsatisfactory conditions. Hamilton can be regarded as the only infested area under our jurisdiction causing concern at the present time. Its proximity to our stone fruit and grape growing areas makes it doubly important. Japanese beetle collections in Hamilton during 1957 total 230.

Subterranean termites, *Reticulitermes flavipes* (Kollar), were first recorded in Toronto in 1943. Experts who surveyed the situation were of the opinion that it was firmly established and that extermination would be difficult. Since that time, in the area that has been surveyed, there has been some extension of the known infestation.

European earwig, *Forficula auricularia* (L.), was first recorded in Ontario in 1938 near Ayton. It has been recorded in several Ontario centres since that time and was quite prevalent in a section of Toronto during 1946-47. While the population has fluctuated from year to year and no word of infestations in Toronto has been received in recent years, it seems to be firmly established in some areas, and is likely to persist. Its habit of hiding makes it one of the most difficult insects to exclude from an area. It has been intercepted in imports frequently, and undoubtedly has entered undetected in many kinds of merchandise. It is fortunate that these stray insects have not established themselves more readily.

Juniper scale, *Diaspis carueli* Targ., has killed many junipers. In 1955, it had become so prevalent that infestations were reported in 80 nurseries in the Toronto district. Severe losses occurred but by following control recommendations made by Professor Goble, Provincial Entomologist, growers have been able to reduce the infestation. Our officers have been active in urging control, and this year reports of infestations were reduced to 28.

Root weevils have caused damage, especially to evergreen plantings: the black vine weevil, *Brachyrhinus sulcatus* (F.) and the strawberry root weevil, *Brachyrhinus ovatus* (L.) have been most notable. *Brachyrhinus raucus* F. was also reported in nurseries in 1954, 1955 and 1957. The latter insect is fairly common in Europe but is apparently a new or very rare pest in this country. The damage by root weevils has been very extensive to *Taxus* and *Thuja* and has done lesser damage to a wide variety of other plants. It has been necessary to refuse exports on a number of occasions due to the presence of these pests.

Juniper webworms, *Dichomeris marginella* (F.) and *Dichomeris ligulella* (Hbn.), have been damaging juniper considerably. Our inspectors recorded these two pests 13 times in 1954, 25 times in 1955, and 38 times in 1956. Infestations extend from Burlington to Bowmanville. They were not quite so numerous in 1957.

Rose sawflies, *Arge ochropus* (Gmel.), were first found in a rose garden in Willowdale by C. S. Kirby of the Forest Biology Division, Canada Department of Agriculture, in 1951. The following year, officers of this division found it in a nursery, and a number of private gardens. It has spread since that time, and is firmly established both north and west of the city of Toronto. It was found in

eight nurseries this year. While readily controlled, it is now in enough of the unattended plantings to make it one of our new and established pests. Spread seems to have been unusually rapid.

Honey locust pod gall midges, *Dasyneura gleditschieae* O.S., were reported twice in 1956, and in seven nurseries in 1957. It is causing serious distortion and damage to Moraine and Sunburst locust. Controls are apparently dependent on careful timing and discouraging results were obtained this year.

Ermine moths, *Yponomeuta cognatella* Hbn., pests of *Euonymus* in Europe, were discovered during nursery inspection at Agincourt in 1954. This was the first North American record. Prompt action was taken to trace all plants which had been sold or remained in the nursery. These were destroyed, and no further trace of the pest was recorded until 1957 when several pupae of this species were found in *Malus hopa* imported late in 1956.

Hollyhock weevils, *Apion longirostre* Olive., have been recorded during the past 4 years in various nurseries in the Toronto area.

Genista caterpillars, *Tholeria reversalis* Guen., were found during nursery inspection in 1952, 1954, and 1955 on laburnum. It was found in ten nurseries in 1954 but was not recorded in our reports for either 1956 or 1957.

Privet sawflies, *Macrophya erythropa* (Schr.), have been reported on privet or syringa every year since 1952. It was reported in 14 nurseries in 1955, nine in 1956 and more than 25 in 1957.

Barberry geometrids, *Coryphista meadi* Pack., first found in 1956, were found in five nurseries in 1957 widely spread, and appear to be a new pest preferring one of our hitherto almost insect-free plants. It is most common on the purple varieties of barberry.

Spiraea sawflies, *Pristiphora bivittata* (Nort.) were first noticed in 1955, reported on two nurseries in 1956, and were quite general on spiraea van Houttei in 1957. Damage was light to moderate.

Brown-headed ash sawflies, *Tomostethus multicinctus* (Roh.), are new pests which were found by Plant Protection officers in London in 1952 and 1953. They were found by Dr. H. C. Coppel at Belleville in 1955. A very light infestation was found in eight trees in the Etobicoke area by officers from the Toronto office in 1957.

Pine borers, *Pinipestis* (possibly *zimmermanni* Grt.), were found in 1957 in one quarter acre of scotch pine in the Oakville area. Two thirds of the trees in a block were infested and severe damage was caused. A second light infestation was recorded at Elgin Mills. This insect has been previously unreported in this area.

We hope that we have been able to convey to you something of our work, and the type of pests we are encountering. We feel that those appearing in our nurseries and which have, or have threatened to, establish themselves, are of particular interest. The examination of dormant plants does not always locate infestations, which in certain stages may be difficult to detect. The follow-up in the nursery has, we believe, proven of equal value to original inspection of importations, and has enabled us to locate and eliminate trace infestations which otherwise might have become widely disseminated. Growers have become much more conscious of entomological problems as a result of the work of Department officiers, and spray programmes are being put into effect, which are giving gratifying results.

(*Accepted for publication: 13 May 1958*)

ECONOMIC AND NON-ECONOMIC RESEARCH

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The relation between economic and non-economic entomology has been a topic of discussion since the establishment of economic entomology. Dr. L. O. Howard, in his history of applied entomology, discussed this rather briefly and concluded that the friction which existed in the early days had been overcome by mutual understanding. In some respects he was at least 27 years premature in his analysis.

Director Emeritus William L. Slate of our Station has a saying that the requirements for successful cooperation are (1) a mutual problem, (2) mutual understanding and (3) mutual respect. There is a mutual problem – insects. The basic researcher is seeking discovery of all the secrets of insect life. The economic entomologist is seeking ways to minimize damage by insects by making use of these secrets. There are countless cases of individual mutual respect and mutual understanding. I saw many of them in August, 1956, when I toured the Ontario laboratories, basic and applied, in company with basic and applied researchers. In the United States we have progressed toward mutual understanding in that a majority of basic entomologists have agreed to join with most of the economic entomologists in a single Society. You, here in Canada, maintain your societies with both groups. Thus we have at least a good start towards mutual understanding on a group basis.

Mutual respect may be stronger between groups than between individuals. Some economic entomologists would describe a basic researcher as a detached and relaxed individual protected from the world by the thick walls of his ivory tower and concerning himself, at his leisure, with some phase of entomology completely untainted by usefulness. He is in no particular hurry to let the rest of the world know what he is doing, lest someone spoil his knowledge by making practical use of it. A composite of the expressions of basic researchers would describe an economic entomologist as a three-way hybrid between public-relations x agricultural-engineer x washtub-chemist, who selects a few plants infested with insects; sprays, counts and weighs; analyses; and rushes into publication before the ink is dry in his notebook.

Absurd as these characterizations may seem there are probably living examples to fit them. But what this means is that a few human beings do not have a strong sense of responsibility. The basis researcher as described, feels little urge to let his fellow scientists know the facts he has found, and the economic entomologist may be implying conclusions on insufficient evidence. These are individual traits and by no means characterize either group. It is not only an unfortunate dis-service to apply them to either group, but also a direct negation of all that we have been taught as scientists.

I feel sure that economic entomologists who stop to think will realize the debt they owe to workers in basic fields for the methods and devices now available. I am equally sure that thoughtful researchers in basic fields can appreciate the ingenuity required to control a pest that has plagued mankind through the whole course of history.

There is always much discussion about the balance between basic and applied research. It is interesting to visit with foreigners in this connection. The researchers from some foreign countries may confess over a mug of beer

that they have found little interesting in research in the United States. The insecticide manufacturers from the same countries usually are highly complimentary. They envy the emphasis on economic entomology which they say is lacking at home. The balance in the United States is heavily toward the economic, and in many respects very weak on the basic side. The recent emphasis on the basic in the United States indicates that we realize this weakness and are trying to correct it.

It is my own feeling that there is no such thing as too much basic research as long as we have problems of the present magnitude. Even if we assume that insecticides are a permanent fixture, we are still woefully short of them. Perhaps basic research on insects will never lead to such a material, but I am in favor of continuing the basic research just the same. The probability of success with this approach is certainly no less than the probability of success with *ad hoc* methods.

There may be too much economic work in the United States, but I doubt it. The technological problems require a very large number of workers. As long as this number is definitely needed, there is no reason to reduce it to bring about a balance. It would be so much easier to increase the basic. Similarly, if an organization seems to be out of balance on the basic side, the trouble may be too few economic entomologists.

This probably sounds unrealistic especially in terms of budgets, taxes and the like. Entomology is certainly well-established. It is my belief that if the need is present and the present staff is doing a good job, there is usually no serious question about getting the money to do a better job.

The type of organization to get good work done in either field is relatively unimportant. There are advantages and disadvantages to any type of organization. As long as the policy is to appoint competent men, to equip them properly, to keep down interruption and red tape, it matters little whether the work is separated by function, by governmental units or any other schemes.

Those of us from south of the border envy you Canadian entomologists. You have already avoided many mistakes in organization and emphasis which we made years ago. You have young, vigorous and capable leadership. Man for man, your researchers are as capable as those of any other nation. We wish you continued success in developing as your country develops.

(*Accepted for publication*: 6 *May 1958*)

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TEST OF A NEMATODE AND ITS ASSOCIATED BACTERIUM FOR CONTROL OF THE COLORADO POTATO BEETLE LEPTINOTARSA DECEMLINEATA (SAY)[1]

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An undescribed species of nematode, related to *Neoaplectana chresima* Steiner (Steinernematidae, Rhabditoidea), and an undescribed species of bacterium associated with it were tested for biological control of the Colorado

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potato beetle, *Leptinotarsa decemlineata* (Say), near Belleville. This is apparently the first attempt to use a nematode as a biological control agent in Canada. Dutky and Hough (1) recovered this nematode and its associated bacterium from diseased codling moth larvae. Dutky infected various species of insects in the laboratory and conducted field trials with this nematode against several insect pests in the United States.

A culture of the nematode and its bacterium was obtained from Dr. Dutky in May, 1957, and his method of mass rearing, in the larvae of the wax moth, *Galleria mellonella* (L.), was used to obtain nematodes for release in the field. In laboratory tests 85 to 100 per cent of the beetle adults and larvae that were infected were killed within 48 hours at 70° F.

The test and the control plot each contained approximately 500 potato plants of the Keswick variety. These were heavily infested by the beetle; the average defoliation was 37 per cent in the test plot and 54 per cent in the control plot. The numbers of the beetle on 25 plants selected at random in each plot were recorded. No natural infection of the beetles was found in the examination of 200 larvae and adults from each plot. On the evening of June 27 approximately 20,000 nematodes of the ensheathed stage were applied per plant with a hand sprayer at a pressure of 250 pounds. Samples taken from the foliage after spraying showed that the nematodes were undamaged by passage through the spray nozzle and apparently were in good condition when they reached the plants.

Five days after the spraying on July 2, beetle adults and larvae on the 50 selected plants were recounted. The average number of beetle adults and larvae per plant had dropped in the test plot from 60.5 ± 6.4 to 39.3 ± 4.4; in the control plot, from $41.4 + 8.2$ to 32.8 ± 7.3. The 35 per cent reduction in the test plot was significant by Student's *t* test at the five per cent level, whereas the 21 per cent reduction in the control plot was not statistically significant.

Recovery of nematodes from dead beetle larvae and adults collected in the field showed that infection had occurred. The effectiveness of the nematodes as control agents was undoubtedly reduced by a rainfall of 1½ inches on the evening of June 29 that probably washed many of them off the plants. Two factors may account for the 21 per cent reduction in the beetle population in the control plot: destruction of the beetle larvae by the heavy rainfall; and the natural disappearance of the larvae into the soil for pupation. If these factors existed to the same degree in the test plot, the nematodes were responsible for at least a 14 per cent reduction in the test plot. The control exerted by the nematodes was small under these conditions, but of sufficient magnitude to merit further investigation.

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(*Accepted for publication: 14 May, 1958*)

III. SCIENTIFIC NOTES AND COMMENTS

NOTE ON REARING THE RED-BACKED CUTWORM, EUXOA OCHROGASTER (GUEN.), IN MASS[1]

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By the following technique, 500 to 1000 of the red-backed cutworm, *Euxoa ochrogaster* (Guen.), may be reared per week per man.

Between 1000 and 1500 eggs are placed, at 70° F. and 65 per cent R.H., on wet blotting paper on a piece of heavy galvanized screen shaped so that its surface is half an inch above the bottom of a glass staining dish, 4 x 3 x 3 in. Eggs hatch over a period of 72 hours after a preincubation period of three to four weeks at 72° F. and a storage period of six weeks at 34° F. The first-instar larvae are divided into groups of 150 and placed in glass culture dishes, eight inches in diameter, with lettuce as food. There is about ten per cent mortality in this instar.

After seven days, the larvae, now in the second instar, are transferred to enamelled wooden trays, 13 x 15 in., containing half an inch of sterilized dry sand. Lettuce is the food, and the leaves are replaced every two days. The larvae complete development and pupate in about four weeks at 76° F. and 65 per cent R.H. There is about 15 per cent mortality during this period. The pupae are placed in glass jars or quart ice-cream containers with moist vermiculite. The moths emerge in about 11 days at 70 to 76° F. and 65 per cent R.H.

Adults for a stock culture are transferred to one-gallon cans, each of which has a screw cap at the top, a screened opening at one side for ventilation, and a bottom of 8-mesh galvanized screening. Each can is placed in a tray of dry sand so that the sand is three-quarters of an inch above the screen bottom. The moths are kept in darkness and are fed a solution of ten per cent honey in distilled water from a plastic pill vial provided with a capillary tube and a wick and suspended on a wire from the screw cap. After a mating period of three to four days, the moths lay their eggs on the surface of the sand and the eggs are removed by sifting the sand.

(Accepted for publication: 21 May 1958)

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NOTE ON OVERWINTERING OF ADORYPHOROPHAGA ABERRANS (TOWNS.), A TACHINID PARASITE OF THE COLORADO POTATO BEETLE[1]

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Adoryphorophaga aberrans (Towns.), a widely distributed parasite of *Leptinotarsa decemlineata* (Say) in North America, has two generations a year. In the summer generation the flies larviposit on the host larvae and the parasite larvae pupate in the dead host larvae. No reference to the overwintering habit was found in the literature.

Several adults of *A. aberrans* were reared from adult Colorado potato beetles in April, 1958. The beetles emerged from hibernation and showed no symptoms of parasitism for about ten days. This suggests that the parasite larvae do not complete their development until after their hosts emerge from hibernation. Ten days after emergence from hibernation the beetles died and the parasite larvae pupated inside them.

(Accepted for publication: 21 May 1958)

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BRACHYRHINUS RAUCUS (F.) IN ONTARIO[1]

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The records of *Brachyrhinus raucus* in North America up to 1947 (Hicks, Canad. Ent. 79, p. 171, 1947) suggested that this European species was established in Ontario. The suggestion has since been confirmed by collections of many specimens in two new localities. The first finding was made by inspectors of the Plant Protection Division, Canada Department of Agriculture, of Toronto, in 1954. During a general nursery survey on June 16 at the Briggs Farm, 9th Line, Trafalgar Township, near Oakville, Halton County, inspectors found this species in numbers on nursery plantings of two junipers, *Juniperus communis* var. *stricta* Carr and *Juniperus chinensis* var. *keteleeri* Cornman; a few were found on a spruce, *Picea pungens* var. *kosteriana* Hort., but none was present on yew, *Taxus* sp. Three years later, the weevil was reported by the same office in two acres of nursery stock of arborvitae, *Thuja occidentalis* L., in the same general area.

The second finding was made by the author on June 18, 1955, in a new section of Britannia Heights, Ottawa. This locality is approximately 14 miles west of Beechwood Cemetery, Ottawa, where the weevil was found in 1943. Twenty-one specimens were collected on and near old, wild raspberry canes, *Rubus* sp., and seedling Manitoba maples, *Acer negundo* L. On August 19 of the next year many specimens were observed inside and outside a new house about a hundred yards away. In the spring of 1957 this species emerged from hibernation near the new home of the author, which is adjacent to the previously mentioned house. It was not possible to record the seasonal occurrence in full, as the author was away during June and July. However, the beetles were becoming more numerous up to June 3 and were present in the immediate area in hundreds from the second week of August until the first week of September. There is evidently an abundant colony of these weevils in a 15-acre area where the soil is light sandy loam, seemingly ideal for the development of a large population.

Series of specimens from the two localities are now in the Canadian National Collection.

(Accepted for publication: 29 May, 1958)

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A NOTE ON SOME ABNORMAL SPECIMENS OF SITOPHILUS GRANARIUS FOUND EMERGING FROM TREATED GRAIN

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In the course of an investigation to observe the effect of repeated exposure of weevils to sub-lethal doses of lindane, some interesting observations have been made that seem worthy of report at this time.

The weevils used in this study were *Sitophilus granarius* (L) the MW strain (1). Preliminary experiments indicated that they could tolerate, as a food supply, wheat grains that had been treated with lindane as follows: — 50 gms. of grain soaked in 100 ml. of 0.0001% lindane in a benzene emulsion for 12 hours and allowed to dry for 48 hours.

In one experiment, 200 weevils were placed on this wheat for one month and then removed. During this period, the females laid eggs. The resulting progeny did not begin to emerge from the grain till 40 days later. The culture had been held at 27°C. and 76% R.H. throughout the experiment.

Among the progeny were five morphologically abnormal weevils that had the front of the head developed in such a way that the rostrum (carrying the mouthparts) was held permanently in an unusual, vertical position. This made locomotion difficult.

The five abnormal weevils were supplied with fresh grain and eventually gave rise to 5 normal progeny. Despite their unusual rostrum formation, they were, thus, apparently able to bore a limited number of oviposition holes.

There is, at present, no explanation for the occurrence of these abnormal weevils. It is anticipated that a fuller account of this work will be available at a later date.

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(Accepted for publication: 28 May, 1958)

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NOTES ON RELATIVE ABUNDANCE AND VARIATION IN ELYTRAL PATTERNS OF SOME COMMON COCCINELLIDS IN THE BELLEVILLE DISTRICT (COLEOPTERA: COCCINELLIDAE)[1]

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A survey of the coccinellids of the Belleville district was made in 1957 as a preliminary to investigations on the feeding and searching behaviour of predatory coccinellids. Collections were made at least weekly within approximately 20 miles of Belleville from *Malus sylvestris* Mill., along with *Rhopalosiphum insertum* (Wlk.), and from *Trifolium pratense* L. and *Medicago sativa* L., along with *Acyrthosiphon pisum* (Harr.), near Foxboro; from *Larix laricina* (Du Roi) K. Koch, along with *Cinara laricifex* (Fitch), near Shannonville; from *Pinus resinosa* Ait., along with *Schizolachnus piniradiatae* (Davidson) and *Schizolachnus* sp., near Corbyville and Foxboro; from *Artemisia* sp., along with *Coloradoa rufomaculata* (Wilson), near Consecon; and from *Melilotus alba* Desr., along with an unidentified aphid, at all these localities. Collections were made less frequently from *Pinus* spp. and other plants near Algonquin Park, Weslemkoon Lake, and Madoc, and also in debris washed up along the shore of Lake Ontario near Consecon. The adults were usually picked by hand except from alfalfa and clover, where a net was used. Specimens of the coccinellids were identified by Mr. R. de Ruette and of the aphids by Dr. W. R. Richards of the Entomology Division, Ottawa.

The total number of adults collected was 2,300, of which approximately 97 per cent represented nine species for each of which there were 50 or more specimens. Of the total, the percentage for each species, and the host plants, were as follows: *Coccinella trifasciata perplexa* Muls.: 36, on all the hosts listed; *Coleomegilla maculata lengi* Timb.: 14, on all except apple, pine, and larch; *Coccinella novemnotata novemnotata* Hbst.: 13, on all except larch; *Hippodamia parenthesis* (Say): 10, on all except corn and larch; *Coccinella transversoguttata quinquenotata* Kby.: 8, on all hosts; *Adalia bipunctata* (L.): 5, on apple, wormwood, and white clover; *H. tredecimpunctata tibialis* (Say): 5, on all except apple and larch; *Cycloneda sanguinea* (L.): 4, on alfalfa and red clover, white clover, and wormwood; and *H. convergens Guerin*: 2, on wormwood. All these species except *A. bipunctata* were also found in the debris along the lakeshore. The remaining three per cent of the collection represented: *Chilocorus stigma* (Say) and *Coccinella nivicola monticola* Muls., from apple; *Anatis mali* auct., from larch and pine; *Adalia frigida* (Schn.), *Mulsantina* sp., *Neomysia* sp., *Hyperaspis* sp., and *Scymnus* sp., from pine (the first three at Algonquin Park and Weslemkoon Lake); *Brachyacantha ursina* (F.) and

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Adalia humeralis (Say), from white clover; *Anatis quindecimpunctata* (Oliv.), from wormwood; and *Hippodamia glacialis glacialis* (F.) and *Neoharmonia venusta* (Melsh.), in the debris at the lakeshore.

The various elytral patterns for the species of *Hippodamia* are described with reference to Chapin's (1) figures. Ninety-eight per cent of *H. tredecimpunctata* had 13 unjoined spots (as in Fig. 52), and two per cent had spots 4 and 5 joined (as in Fig. 50). Fifty-five per cent of *H. parenthesis* had spots 4, 5, and 6 joined and spot 2 absent (as in Fig. 70), 21 per cent had 4, 5, and 6 joined and 2 present (as in Fig. 68), 18 per cent had 4 and 6 joined, 5 separate, and 2 absent (as in Fig. 71), and six per cent had 4 and 6 joined, 5 separate and 2 present. Ninety-seven per cent of *H. convergens* had spots 13 all unjoined (as in Fig. 152). The remaining three per cent included specimens with the full complement of spots but with 4 and 5 joined (as in Fig. 150), and specimens with various reductions in the number of spots, i.e., with spot 1 absent, with 5 absent, with 1, 4, and 6 absent, and with 1, 4, 5, and 6 absent.

Variation in the spot patterns of species of *Coccinella* corresponded generally to Dobzhansky's (2) descriptions. Slightly more than 99 per cent of *C. trifasciata* had anterior, median, and posterior fasciae. Atypical specimens had the following modifications: spots 2 and 3 unjoined; spots 1 and 1/2 unjoined; and medial and posterior fasciae joined along the mid-line. Ninety-five per cent of *C. novemnotata* had the spots unjoined, four per cent had spots 1 and 2 joined by a continuous or interrupted line, and the remaining one per cent included specimens with spots 3 and 4 joined, spots 1 and 2 and 1 and 3 joined, and spots 1 and 2 and 3 and 4 joined. Fifty-seven per cent of *C. transversoguttata* had subbasal fascia, subapical fascia, and spot 3 present and 2 absent; 42 per cent were similar except that spot 2 was present; and one per cent had the subbasal fascia and spot 3 reduced and spot 2 absent.

Variation in the spot patterns of *A. bipunctata* and *C. maculata* was slight. All specimens of the former were red with a black spot of varying size on each elytron. Ninety-nine per cent of *C. maculata* had the common spot 1/2 and five unjoined spots on each elytron. Spots 4 and 5 were joined in one per cent of the specimens.

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(Accepted for publication: 30 May 1958)

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NOTE ON OCCURRENCE OF TARANTULA SPIDERS (MYGALOMORPHAE) IN CANADA[1]

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The suborder Mygalomorphae, which includes the so-called tarantulas, is poorly represented in Canada. Grey (1) reported *Atypus niger* Hentz from Ontario and Leech (2) reported that a specimen identified by Gertsch as of *Anthrodietus* sp. was collected at Oliver, B.C., by A. A. Dennys. A third record is provided by a trap-door spider collected near Kelowna, B.C., on April 1, 1954, by C. L. Nielson, identified as a female of *Anthodietus pacificum* (Simon).

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(Accepted for publication: 21 May 1958)

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IV. REVIEWS & REPORTS

SUMMARY OF IMPORTANT INSECT INFESTATIONS, OCCURRENCES AND DAMAGE IN CANADA IN 1957[1]

C. GRAHAM MACNAY[2]

This summary of insect conditions in Canada in 1957 was prepared from regional reports submitted by officers of the Entomology Division, Provincial Entomologists, officers of the Plant Protection Division, Canada Department of Agriculture, and University Professors. In general, common names used are from the 1955 revision of the list approved by the American Association of Economic Entomologists. To avoid unnecessary duplication, forest insect conditions are not included, this being adequately dealt with in the *Annual Report of the Forest Insect and Disease Survey* published by the Forest Biology Division, Canada Department of Agriculture.

GENERAL-FEEDING AND MISCELLANEOUS INSECTS

BEET WEBWORM.—In British Columbia, the beet webworm caused minor damage to spinach at Lavington and asparagus at Kamloops. In Alberta, rape, mustard, flax, and safflower in dry areas were seriously injured. In Saskatchewan, infestations occurred at Elda, Nipawin, Kenaston, and Saskatoon. Flax and rape were attacked, some fields being damaged severely. In Manitoba, increased numbers were reported.

BLISTER BEETLES.—In Saskatchewan, *Lytta nuttallii* Say severely damaged a new strain of sweet clover at Saskatoon and occurred in large numbers at Outlook. In Manitoba, increased numbers of *L. nuttallii, Epicauta fabricii* (Lec.), and *E. subglabra* (Fall), apparently associated with larger numbers of grasshoppers, damaged potatoes and broad beans at Brandon. In southern Quebec, small numbers of *E. pennsylvanica* (DeG.) were observed on potatoes.

CRICKETS.—Crickets were considered minor pests in most Provinces. In Manitoba populations remained high where grasshoppers were abundant. In Prince Edward Island they continued to be very scarce.

CUTWORMS.—In the interior of British Columbia, areas of infestation and damage by cutworms were the greatest in four years. In agricultural areas of Kamloops, Salmon Arm, Armstrong, and the northern Okanagan Valley, tomatoes, beans, beets, and asparagus were severely damaged; melons, peas, and alfalfa were also affected. The red-backed cutworm was the most common species. During the summer, potato foliage was damaged by the bertha armyworm at Soda Creek and Grand Forks. At the latter point the variegated cutworm also contributed to the damage.

In Alberta, an extensive infestation of the red-backed cutworm occurred in parkland and adjacent prairie areas. Considerable damage was done to barley, oats, wheat, flax, and rapeseed near the foothills from High River to Claresholm. Some localized increases in numbers of the pale western cutworm were noted, but damage was light. The armyworm was abundant in southern agricultural areas, but larval development was early and losses were avoided to a great extent by late seeding. Increased numbers of cutworms are expected in 1958.

In Saskatchewan, the pale western cutworm was more numerous than in 1956, but significant damage occurred in only a few fields. The red-backed cutworm was more abundant and more widely distributed than for many years, being present in half of the fields surveyed from Humboldt and Watrous northwest to Wilkie and Lloydminster. The bertha armyworm was much less numerous than in 1955 and 1956. Infestations at Pike Lake, Nipawin, Kenaston, and Saskatoon damaged flax and rape. The army cutworm occurred in moderate numbers in southwestern Saskatchewan, over half of the cropped fields in the Shaunavon-Eastend area being infested, but pupation occurred before most crops attained a susceptible stage of growth. *Euxoa tristicula* (Morr.) occurred locally in stubble of flax and rape in central agricultural areas of Saskatchewan. A heavy infestation of *Chorizagrotis thanatalogia* (Dyar) was found in a field at Dundurn. The glassy cutworm was numerous at Saskatoon. The armyworm, the wheat head armyworm, and *Polia lilacina* (Harv.) were not reported.

In Manitoba, the red-backed cutworm and other species were more injurious to vegetables and ornamentals than for two or three years at Winnipeg and Brandon. The armyworm, the army cutworm, and the bertha armyworm were not observed.

In southwestern Ontario, several local outbreaks of the armyworm occurred in Kent, Brant, Middlesex, Elgin, and Norfolk counties. Most infestations originated in winter wheat and hay, but oats, corn, and barley in adjacent fields were extensively damaged. Some minor

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infestations occurred in south-central and eastern Ontario. The black cutworm, more numerous than in 1956, injured crops in isolated areas. Tobacco was commonly attacked and corn and sugar beets on Walpole Island were severely damaged. The variegated cutworm, too, occurred in increased numbers, attacking tobacco and other crops. The spotted cutworm was commonly found with the armyworm.

In Quebec, cutworms caused moderate to severe damage to various seedlings and transplants. At St. Jean, armyworm adults were taken in light traps in the largest numbers in several years.

In New Brunswick, cutworm damage in blueberry plantings was generally light, although a general increase in the population of armyworms occurred. The fall armyworm was almost as injurious to corn as the corn earworm. The black army cutworm increased in numbers in Charlotte County, control measures being necessary on two farms.

In Nova Scotia, the bronzed cutworm increased to moderate intensity in the Cow Bay area and the armyworm occurred in small outbreaks at Medford and Upper Canard. Other species were scarce.

In Prince Edward Island, the variegated cutworm was more numerous than usual, mainly in gardens and truck crops. The red-backed cutworm occurred in one grain field and no armyworm damage was reported.

In Newfoundland, the armyworm caused extensive damage to oats in the St. John's area. The black cutworm severely damaged turnips and cabbage and was injurious to vegetables in bogland areas.

EUROPEAN EARWIG.—In British Columbia, this pest caused the usual annoyance in coastal areas and continued to decline in numbers in interior fruit-growing areas. In southwestern Ontario it continued to spread.

GRASSHOPPERS.—In British Columbia, economic infestations of grasshoppers occurred in scattered areas. Over 5,000 acres of range land were sprayed in the Nicola Control Zone. Some range land and forage crops in the Princeton Control Zone and some orchards in the southern part of the Okanagan Valley were sprayed. Local concentrations were sprayed at many other points. Very few economic infestations were observed north of Empire Valley and Pavilion Mountain. *Melanoplus mexicanus* (Sauss.) was the most abundant species on weedy range lands. *Camnula pellucida* (Scudd.) was also generally distributed and was the major species on Pavilion Mountain and in the Boundary and Peace River districts. *M. femur-rubrum* (DeG.) was more numerous than for many years and was the major species at several points in southern British Columbia, especially in irrigated areas of the Okanagan Valley. *M. bivittatus* (Say), conspicuously absent in central and northern areas, was common in southern valleys. *Amphitornus coloradus* (Thos.) was common in range lands and the principal species in spear grass areas. *Dissosteira carolina* (L.) was more noticeable than usual, especially in the Okanagan Valley. *Trachyrhachis kiowa* (Thos.) was recorded as a pest for the first time in the Province when it occurred in a severe local infestation on range land near Kamloops.

In southern agricultural areas of Alberta, damage was negligible despite larger populations of the three main species. *C. pellucida,* scarce in recent years, increased noticeably, but *M. bivittatus* and *M. mexicanus* were the principal species. Damage in the southern areas in 1958 is expected to be the greatest in several years.

In Saskatchwan, severe outbreaks in southeastern and south-central agricultural areas, together with widely scattered, local outbreaks elsewhere in the Province, required the use of about 12,000 gal. of insecticide. The following were the main areas of infestation: Gainsborough-Carnduff, Oungre-Minton, Big Beaver-Wood Mountain, Glentworth, and LaFleche-Ponteix. The forecast for 1958 indicates an increase both in numbers and in areas of infestation. In southeastern agricultural areas, *M. mexicanus* and *M. bivittatus* were the main pests. In south-central areas, westward to Leader and northward to Delisle, *C. pellucida* caused most damage. Severe drought in west-central Saskatchewan was believed to have retarded oviposition.

In Manitoba, infestation reached forecast expectations on lighter soils only. Very heavy rains in parts of the Red River Valley during the hatching period prevented populations from reaching outbreak proportions. Moderate to severe infestations occurred in the Neepawa-Gladstone-Carberry, Pipestone-Melita-Lyleton, and Carman-Graysville districts during the summer. In these districts alfalfa and pastures suffered and marginal damage to grain crops was common. Some head clipping of oats and flax also occurred. On heavier soils damage was marginal. Areas of light infestation occurred in the St. Anne, St. Pierre, and Dominion City districts east of the Red River. Light and moderate infestations occurred northeast and northwest of Winnipeg. Infestations in the Brandon, Neepawa, Gladstone, Carberry, and Glenboro districts and the southwestern part of the Province were mainly moderate, and were surrounded by areas of light infestation. On lighter soils, *M. mexicanus* was the major species with *M. bivittatus* secondary and *C. pellucida* and *M. packardii* Scudd. also present. *C. pellucida* was more numerous and widespread in the southwestern part of the Province than in previous years. In areas of heavier soil, roadsides were infested; *M. bivittatus* was the most abundant species, with *C. pellucida* secondary and *M. mexicanus* in trace numbers.

In Eastern Canada, with few exceptions, grasshoppers were of minor economic importance. Some local abundance, mainly in oat fields, was reported in the St. Jean and Ste. Sabine areas of Quebec.

INSECTS FEEDING ON WEEDS.—*Trirhabda pilosa* Blake, which was first observed feeding on sagebrush, *Artemisia tridentata* Nutt., near Kamloops, B.C., in 1954, has spread steadily and now occurs in about four square miles of range land, many plants having been killed. A chrysomelid, *Gastrophysa polygoni* (L.), fed commonly on wild buckwheat in central agricultural area of Saskatchewan. At Moose Jaw, Sask., it occurred on knotweed, *Polygonum* sp. Another chrysomelid, *Calligrapha californica coreopsivora* Brown, fed on the weed *Bidens cernua* var. *dentata* (Nutt.) Boivin in coastal British Columbia. In Prince Edward Island, *Cnephasia virgaureana* Tr. fed on various weeds and cultivated plants. In Quebec, the red admiral freely attacked weeds in the lower St. Lawrence Valley.

JUNE BEETLES.—The only damage reported in Western Canada occurred in the Agassiz Forest Reserve, Man., where young trees in a nursery were severely damaged. In Ontario, the extreme southwestern region and the Niagara Peninsula were comparatively free of damage, but a severe infestation of second-year larvae caused extensive damage, particularly to turf and sod, in most of the agricultural areas of the Province. *Phyllophaga fusca* (Froel.) was the most numerous species in eastern Ontario. In south-central and western areas to Lake Huron, *P. fusca, P. rugosa* (Melsh.), *P. futilis* (Lec.), and *P. anxia* (Lec.) were all represented. In some areas strawberries were severely attacked. Skunks further disfigured damaged turf by rooting up the loose sod. Severe damage is usually followed by heavy weed growth, adding to the problem of re-establishment. In Quebec, considerable damage was caused in the Ottawa Valley by an extension of the Ontario infestation and, in the south, damage was reported from Lake St. Jean and Ste. Anne de la Pocatiere. Heavy flights of beetles also occurred in southern areas. In New Brunswick lawns were damaged in St. John, Kings, and York counties. In Nova Scotia a lawn at Centreville was severely damaged and in Prince Edward Island considerable injury to lawns and potato tubers was reported.

PAINTED-LADY.—This insect was unusually numerous from Manitoba to Nova Scotia. In Manitoba, sunflower and sugar beets were damaged.

A SAP-FEEDING BEETLE.—*Glischrochilus quadrisignatus* (Say) was unusually injurious to corn, tomatoes, and raspberries in southwestern Ontario, especially in Oxford County.

SIX-SPOTTED LEAFHOPPER.—A general outbreak of this leafhopper caused severe damage to flax, carrots, beets, lettuce, corn, potatoes, and celery in the Prairie Provinces and Ontario; yellows and purple top were common.

WIREWORMS.—In British Columbia, *Agriotes obscurus* (L.) continued to extend its range very slowly at Agassiz. At Ladner, *Ctenicera lobata caricina* (Germ.) and *A. sparsus* Lec. continued to cause damage to potato. In the Cariboo and Peace River districts, several species were reported. In the latter area light to moderate damage occurred in barley in the Grand Haven and Gundy districts. No serious damage was reported from the interior of the Province.

In Alberta, damage in spring cereal crops and sugar beets was again very light, largely because of dry weather. Several reports of damage to vegetables and strawberries were received.

In Saskatchewan, wireworm damage was found in 142 of 244 fields of cereal crops examined; thinning was estimated to average 3.5 per cent. Little severe injury was observed. Most of the moderate damage was confined to wheat on summer-fallow in west-central and southeastern agricultural areas; barley and oats were less affected. Damage to all stubble crops was light; no damage was observed in rape and only light thinning in flax.

In Manitoba, the prairie grain wireworm was normally numerous in the western part of the Province, but caused little damage, mainly because of good growing conditions.

In Ontario, the wheat wireworm caused local damage to tomatoes in Kent County. Injury by the eastern field wireworm in southwestern Ontario was very light, mainly because of effective control measures.

In southern Quebec, several wireworm species injured radish, corn, and potatoes growing in muck soils.

In the Atlantic provinces, the wheat wireworm severely damaged Katahdin potatoes at Fredericton, N.B., and caused only slight damage to Green Mountain potatoes growing beside them. In the Annapolis Valley and Hants County, N.S., this wireworm injured potatoes and *Agriotes sputator* (L.), *A. obscurus,* and *A. lineatus* (L.) were normally abundant. In the western part of Prince Edward Island, unidentified wireworms damaged potatoes on six farms. Wireworm damage to potatoes was reported in the Province for the first time in 1956. In Newfoundland, potatoes and some other vegetable crops were damaged in a few areas.

FIELD CROP INSECTS

APHIDS.—In British Columbia, the English grain aphid caused somewhat less damage than usual to grain in the lower Fraser Valley, but occurred in outbreak numbers at Creston.

In the Prairie Provinces, the pea aphid occurred on alfalfa in southern agricultural areas of Alberta in the heaviest infestations since 1946. In Saskatchewan, some heavy infestations of *Macrosiphum* sp. were observed on flax at Zealandia and Kindersley and light infestations of the turnip aphid occurred on rape in the central agricultural areas; aphids attacked rape also at Prince Albert. In Manitoba, no aphid damage was reported, although the pea aphid and the corn leaf aphid were observed, the latter on barley and corn. *Myzocallidium riehmi* Borner occurred in non-injurious numbers on sweet clover.

In Ontario, the corn leaf aphid was widely reported in appreciable numbers on corn, but did not require control measures. In the Ottawa Valley, winged adults were very numerous on tomatoes in early August but caused no damage. The pea aphid was abundant on alfalfa in Kent County and was generally present in light infestations on canning peas. The English grain aphid was scarce in southwestern counties. In Quebec the corn leaf aphid severely damaged some late barley at St. Jean and injured corn lightly in many areas. In New Brunswick and Nova Scotia and Prince Edward Island, the English grain aphid caused minor damage to oats and barley.

BARLEY JOINTWORM.—In Prince Edward Island, the barley jointworm caused no serious damage in Kings and Queens counties, but in eastern Prince County, where infestation was more recent, about 60 per cent of the barley was infested.

CLOVER-INFESTING WEEVILS.—In Alberta, where the alfalfa weevil was first recorded in 1954, this species now occurs in large numbers in most fields south of the Oldman and South Saskatchewan rivers and has been found as far north as Hays. In Saskatchewan, little change in numbers was noted and no infestations were found outside an area extending 100 miles north of the International Boundary and from Alberta eastward to within 65 miles of Manitoba. Damage was of minor importance. Normal populations of the sweetclover weevil damaged seedling sweet clover at various points in the Province. In Manitoba, control measures were necessary in second-year clover plots in the Winnipeg area and at Brandon losses occurred in seedling sweet clover. At Wanless, Man., *Sitona scissifons* Say (=*S. tibialis* of American authors (occurred in considerable numbers in one field of alfalfa and in southern agricultural areas of the Province was fairly common. In eastern Ontario, the clover head weevil was scarce. In eastern Quebec, the clover root borer and a clover root weevil, *Sitona* sp., caused minor damage.

CORN EARWORM.—In British Columbia, the corn earworm fed on tomatoes at Smithers and on corn at Quesnel and Salmon Arm. No reports were received from the Prairie Provinces. In southwestern Ontario, adults appeared early and the larvae caused much damage to canning corn. Reports from southern Quebec indicated no unusual damage. In the Atlantic provinces, late emergence and cool weather greatly retarded damage in all provinces but Newfoundland, where 100 per cent infestation of sweet corn occurred in some gardens.

EUROPEAN CORN BORER.—A survey of corn plots in an area 84 miles by 54 miles in the southeastern corner of Saskatchewan showed 63 per cent of the plots to be infested, one to 60 per cent of the plants being affected. This is a considerable reduction from infestations in 1955 and 1956, but cob damage was somewhat greater. New infestations at Val Marie and Maple Creek indicated a westward spread of at least 100 miles since 1955 in southwestern agricultural areas. In Manitoba, the insect was abundant at Morden and Carman, moderately scarce at Brandon, scarce at Winnipeg, and not recorded at Dauphin. The annual survey in southwestern Ontario showed infestation to be the lightest since 1954. The average infestation in 90 fields was 26 per cent, as compared with 39 per cent in 1956 and 41 per cent in 1955. The average number of borers per 100 plants was 33 as compared with 101 in 1956. The greatest reduction was in Essex County. However, pockets of severe infestation occurred in all counties in the area. Second-generation borers occurred in the smallest numbers in several years. In eastern Ontario, an increase in numbers was reported. In four districts in southwestern Quebec, infestation of corn plants averaged nine per cent. The average number of borers per infested plant was approximately 0.3. These averages were less than half those recorded in 1956. Ear infestation at harvest averaged 17 per cent. In the Montreal district, ear infestation in canning corn averaged 7 per cent. In New Brunswick damage generally was light.

LEAFHOPPERS.—*Empoasca* sp. caused slight damage to alfalfa at Smithers, B.C., and *E. fabae* (Harr.), present in increased numbers, caused severe hopperburn on alfalfa in southwestern Ontario. In Saskatchewan, the incidence of yellows in flax, transmitted by the six-spotted leafhopper, was the highest on record, losses ranging from a trace in the west to 60 per cent in parts of the eastern park belt.

LEGUME-POLLINATING INSECTS.—Since 1952, there has been a steady decline in the population of *Megachile perihirta* Ckll. on alfalfa and clover in southern agricultural areas of Alberta and seed yields have varied consistently with the fluctuating numbers of this important pollinator. However, yields in 1957 should be better, as drought largely eliminated competing bloom on the nesting habitats of the pollinators, forcing them to fly to the irrigated alfalfa fields for food. Lower seed yields in red clover may be attributed to smaller numbers of bumble bees (apparently populations of bumble bees also are declining) and to a lack of

honey bees. In Saskatchewan, queens of *Bombus terricola* Kby., *B. ternarius* Say, and *B. borealis* Kby. were numerous in the spring on native flowering plants in the Nipawin district, but workers did not develop in the numbers expected and populations were smaller than in 1956. However, favorable weather during the legume seed-setting period greatly enhanced the value of the smaller numbers. In Manitoba, the leaf-cutter bee population in the Wanless area was larger than in 1956, but numbers were still so small that they were seldom observed during routine counts of bees on alfalfa. The average number of *B. terricola* on alfalfa was satisfactory, reaching a high of 0.75 per sqare yard.

PLANT BUGS.—In British Columbia, plant bugs, mainly *Liocoris unctuosus* Kelton and *L. borealis* Kelton, were present in economic numbers in every alfalfa field inspected in the seed-growing districts of the Peace River area. *Labops hesperius* Uhl. caused considerable damage to *Poa* spp., *Festuca* spp., and *Agropyron* spp. in lawns and pastures at the Canada Experimental Sub-station, Mile 1019, Alaska Highway, Yukon Territory. A few alfalfa fields in the Rock Creek district were heavily infested with *Plagiognathus* sp. and considerable bud blasting and stunting resulted. In Saskatchewan, the populations of *Liocoris* spp. were generally larger over the whole alfalfa seed-growing area in the northeastern agricultural part of the Province than in any year since 1946. As many as 60 per sweep were recorded in the Pas Trail district. Severe damage occurred in nearly all fields that were not treated with insecticide. *Plagiognathus* sp. was less abundant than in 1956, probably because many of the older alfalfa plantings were being ploughed down. *Adelphocoris lineolatus* (Goeze) was no more abundant than in 1956, but was more evenly distributed and occurred commonly in red clover as well as alfalfa. *A. rapidus* (Say) appeared in small numbers, as in previous years. In Manitoba, the tarnished plant bug occurred in numbers up to 2.5 per net sweet on alfalfa in the Wanless area. *A. lineolatus* and *A. rapidus* were again present in small numbers. In the Ottawa Valley, Ont., *A. lineolatus* occurred in normal numbers, somewhat reduced from those of 1956. The tarnished plant bug was again present in subnormal numbers on clover and alfalfa and *Plagiognathus chrysanthemi* (Wolff) was, as usual, abundant on alfalfa, red clover, and birdsfoot trefoil.

SEED-CORN BEETLES.—About 40 acres of corn near Dresden, Ont., were severely damaged by *Agonoderus* sp. and *Clivina impressifrons* Lec.

SOD WEBWORMS.—In Nova Scotia, *Crambus* sp. occurred in outbreak numbers in Pictou, Antigonish, and Gusboro counties. They caused up to 85 per cent reduction in yield in some strawberry plantings and severely damaged grain, legumes, and other crops.

SPITTLEBUGS.—On Lulu Island, B.C., the meadow spittlebug occurred in exceptionally large numbers on wild blackberry and weeds, but was not important on cultivated fruits. In southwestern Ontario, cool weather delayed development of this pest and damage to clover and alfalfa was not extensive; injury to strawberries was more commonly reported. Numbers in the Ottawa Valley were about normal, being reduced from those of 1956. In southeastern Quebec, the insect was abundant but damage was light.

SUGAR-BEET INSECTS.—At Taber, Alta., the sugar-beet root maggot damaged beets for the third successive year, some 3,000 acres being treated with insecticides. In Manitoba, this root maggot was less abundant than usual in the light soil area about Altona-Winkler and damage was light. In southwestern Ontario, no infestations of the sugar-beet root aphid were reported.

SUNFLOWER INSECTS.—Insect damage to sunflowers in Manitoba in 1957 was generally light, despite considerable damage to leaves by larvae of the painted-lady and by larvae and adults of the sunflower beetle. Damage to seeds by the banded sunflower moth dropped from 2.5 per cent in 1956 to 1.0 per cent in the main sunflower-growing area. The sunflower moth, a very destructive pest of sunflowers. was present in some fields. Parasites have held it and the banded sunflower moth in check. A weevil, *Rhynchites aeneus* Boh., was numerous in a field near Sommerfield. This pest decapitates sunflowers. Nine per cent of the heads were cut off along the margin of a field northwest of Altona. The sunflower beetle was more numerous than it had been since 1952; it caused more leaf damage than usual in some fields, but little reduction in yields. Extensive damage by the painted-lady, the first since 1949, also caused little reduction in yields. The six-spotted leafhopper was very abundant on crops in southern Manitoba and aster yellows was very common in sunflower and other crops.

THRIPS.—The only damage by thrips reported in Alberta occurred on oats at Berwyn. In Saskatchewan, *Haplorthrips niger* (Osb.) was present in small numbers in all red clover fields sampled in northeastern agricultural areas. The insect caused some concern to seed producers, but no evidence of economic damage was observed. In Manitoba, thrips were present on barley in some areas, but caused little damage. In Ontario, *Anaphothrips obscurus* (Müll.) was not abundant on cereals and grasses in the Ottawa area, but moderately damaged oats and corn in Carleton, Lanark, and Grenville counties.

TOBACCO INSECTS.—In southwestern Ontario, cutworms caused minor damage to tobacco. The tomato hornworm and the tobacco hornworm were more numerous than in

1956 and control measures were general. Heavy infestations of the green peach aphid developed on many individual plants. Light damage was caused by the celery looper in the Port Stanley area and the spotted cucumber beetle at Highgate. The zebra caterpillar moderately damaged flue-cured tobacco in Norfolk County. The cornfield ant, *Lasius alienus* (Foerst.), severely infested a tobacco seed bed.

WHEAT MIDGE.—In British Columbia, light infestations of this insect occurred on both spring and fall wheats at Armstrong and in one field south of Armstrong. In the Red River Valley, Man., the midge has caused considerable damage to wheat annually since it was first observed in 1955. In 1957 the areas most seriously affected were Pigeon Lake, Portage la Prairie, Morris, Winnipeg, Starbuck, and Altona. The most severe damage occurred at Pigeon Lake, losses amounting to 13.6 per cent.

WHEAT STEM MAGGOT.—In Alberta some damage occurred on wheat at Vegreville. In Manitoba the insect occurred in normal abundance and in southwestern Ontario no infestation was found, contrasting with a moderate outbreak in 1956.

WHEAT STEM SAWFLY.—In Alberta, damage generally remained at a low level, although increases were recorded in southeastern agricultural areas. The large acreage of resistant durum wheats, and other unfavorable hosts such as mustard and flax grown in southern areas, were major controlling factors. Severe infestations occurred in small areas southeast of Lethbridge and northeast of Medicine Hat. A marked reduction in the sawfly population at Hilda resulted from use of resistant varieties of wheat and from high parasitism. A decrease in damage occurred also in the area between Barons and Arrowood. In Saskatchewan a general increase in severity occurred in the southwest portion. Severe infestations occurred east of Consul and south of Shaunavon, but the Regina plains remained remarkably free of damage. Moderate infestations occurred in small areas east of Saskatoon and at Humboldt, Delisle, Riverhurst, Cabri-Leader, Gravelbourg, Kincaid, and Assiniboia. In Manitoba infestation remained very light. In Ontario, only minor infestations of the European wheat stem sawfly were observed and no damage was reported.

VEGETABLE INSECTS

ALFALFA LOOPER.—This insect again occurred in minor outbreaks on lettuce at Cloverdale, B.C.

APHIDS.—In British Columbia, the sugar-beet root aphid fed on the roots of lettuce and dandelion. At Abbotsford, control measures were necessary against the cabbage aphid on crucifers, especially Brussels sprouts and broccoli. The green peach aphid and the potato aphid were present on potato, the former becoming numerous late in the season in most areas. In the lower Fraser Valley, control measures were carried out against the pea aphid. In Saskatchewan, aphids on vegetables were generally less numerous than in 1956. The cabbage aphid and the sugar-beet root aphid caused some damage at Regina and the corn leaf aphid caused little damage. In Manitoba, aphids on vegetables generally were more abundant than in 1956. In southwestern Ontario, the melon aphid was widely reported and was injurious to cucumbers. At Burlington, Ont., large numbers of aphids developed on celery. In the Ottawa Valley, the cabbage aphid was less abundant than usual, but severe local infestations developed on cabbage in the Holland Marsh and in Prince Edward County. The green peach aphid was more abundant than usual on crucifers at Ottawa. In southern Quebec, the pea aphid and various potato-infesting aphids caused only minor damage, weather conditions being unfavorable for development. In New Brunswick, aphid infestations on potatoes were the most severe since 1950 in the Lincoln area and parasites were conspicuously absent. In Nova Scotia, the pea aphid was more numerous on potatoes than in 1956 and was very injurious in the Annapolis Valley. The cabbage aphid, apparently imported on seedlings, was very injurious to field cabbage at Grand Pré. In Prince Edward Island, the potato aphid was present in generally light infestations in almost every planting. Other species of aphids made up less than five per cent of the aphid population on potatoes.

ASPARAGUS BEETLES.—At Winnipeg, Man., the spotted asparagus beetle was numerous, but not very injurious. In southwestern Ontario, it outnumbered the asparagus beetle by May 30, which was unusual, and caused much defoliation during the season. In eastern Ontario, larvae were conspicuous on foliage in Prince Edward and Hastings counties and at Ottawa the population was the largest in several years. In southwestern Ontario, the asparagus beetle caused considerable early-season damage and at Burlington occurred in a local outbreak. The egg parasite *Tetrastichus asparagi* Cwfd. was abundant.

A BEAN LYCAENID.—At Kelowna, B.C., larvae of *Strymon melinus atrofasciata* McD. damaged pole beans. Although widely distributed in the Province, this was the first record of economic loss.

CATERPILLARS ON CABBAGE.—The imported cabbageworm occurred in normal numbers on cabbage and cauliflower in coastal and interior areas of British Columbia. In Saskatchewan, defoliation of these crops ranged from 30 to 40 per cent as far north as Prince

Albert and Battleford. In Manitoba, the overwintering population was small and migrants were scarcer than usual. In southwestern Ontario, some damage occurred on early cabbage and damage to later crucifers was moderate. Ten acres of cauliflower in the Komoka Marsh were destroyed. In eastern Ontario, the insect became more numerous than usual north of Lake Ontario, but at Ottawa was about average. Without control measures damage would have been generally severe in the Province. In southern Quebec, emergence was late and infestations were light. In the Atlantic provinces, too, numbers were generally reduced except in Prince Edward Island, where moderate abundance was reported. In Newfoundland, the scarcity of adults was conspicuous.

The diamondback moth occurred in moderate numbers in coastal British Columbia, but was not reported in the Prairie Provinces. In southwestern Ontario, it showed some increase and damaged early, as well as late, cabbage. At Ottawa, populations were normal. In Prince Edward Island considerable damage occurred in rutabagas and cabbage. In Newfoundland infestation was light.

The cabbage looper was not reported in Western Canada. In southwestern Ontario, where the insect is rated the number two pest of cole crops, populations compared with those of 1956. In south-central and eastern Ontario, populations were above average and caused severe damage, especially to cabbage and cauliflower. In the Holland Marsh, lettuce was slightly damaged. In New Brunswick and Newfoundland, the insect was numerous and injurious. In the latter province, the purple-backed cabbageworm, more numerous than in 1956, defoliated turnips extensively.

CARROT RUST FLY.—In British Columbia, damage was generally the lightest in several years. In Ontario, surveys made in the Bradford marshes in July and September indicated that the carrot rust fly had failed to become re-established since prolonged flooding in 1954. In Quebec, severe losses occurred in the lower St. Lawrence Valley, including the area around Quebec City. In New Brunswick, damage to carrots and parsnips, although generally light, was severe in the Maugerville-Sheffield area. In Nova Scotia and Prince Edward Island, normal abundance, involving severe damage in small gardens, was reported. In Newfoundland infestation was light.

CARROT WEEVIL.—A survey made in the Bradford marshes, Ont., in July revealed that the area infested by this insect had increased from 150 acres in 1956 to 300 acres. Root damage averaged 15 per cent in the central part of the area.

COLORADO POTATO BEETLE.—Infestation in the Kootenay, B.C., districts was normal. In Saskatchewan the insect occurred in normal numbers in the southern half of the cultivated area of the Province. In Manitoba, emergence was late and damage less than in 1956; tachinid parasitism ranged up to 70 per cent. In southern Ontario, the insect apparently continued to increase in importance, infestation ranging from 100 per cent in home gardens to 15 to 20 per cent in commercial crops. Eastern Ontario was less seriously affected. In Quebec, generally, damage was severe where control was neglected. Small numbers were reported in New Brunswick and normal populations in Nova Scotia and Prince Edward Island. In Nova Scotia, the insect fed on the crowns of newly set strawberries at Medford.

CUCUMBER BEETLES.—The striped cucumber beetle occurred in greatly reduced numbers in Eastern Canada, causing much less damage than in 1956. The spotted cucumber beetle, reported only in southern Ontario, also was less numerous.

FLEA BEETLES.—The potato flea beetle appeared only in small numbers in Manitoba. In southwestern Ontario, it occurred in the largest numbers in several years. In southern Quebec, it was normally abundant and injurious to potatoes, tomatoes, and beans. In the Atlantic provinces, normal early-season numbers were greatly reduced by low temperatures late in June. In Saskatchewan small numbers of *Phyllotreta* spp. caused less damage than in 1956. In Manitoba they were numerous on radish, cabbage, cauliflower and turnips and abundant in some fields of rape in the interlake area and at Portage la Prairie. At Ottawa, *P. striolata* (F.) caused serious damage to Brussels sprouts and rutabagas and an undetermined species of *Phyllotreta* caused widespread damage to various crucifers. In New Brunswick, *P. striolata* was numerous until late in June, when it disappeared. In British Columbia, the tuber flea beetle caused little damage in the lower Fraser and Okanagan valleys. Moderate numbers at Armstrong were controlled.

GREEN CLOVERWORM. — This insect damaged 5 to 10 per cent of white bean plants in some fields in Kent County, Ont.

HORNWORMS.—The tomato hornworm was much less numerous than usual in eastern Ontario.

LEAFHOPPERS.—The six-spotted leafhopper occurred from Alberta to western Quebec in one of the most severe outbreaks on record. Flax, carrots, beets, lettuce, corn, potatoes, celery, cucumbers, onions, parsnips, tomatoes, peppers, dill, and many ornamentals were severely damaged. Infection by the yellows virus resulted in the complete loss of many crops of head lettuce, and carrots in Saskatchewan, Manitoba and Ontario. Purple top affected up to 40 per cent of potatoes in Saskatchewan and was common elsewhere. In this province, too, up to 40 per cent

of cucumber plants and 50 per cent of peppers and tomatoes in market gardens died from virus disease. No unusual numbers were reported east of the Ottawa River Valley, except in eastern Nova Scotia and Cape Breton Island, where the insect was very numerous in carrot and lettuce crops. The potato leafhopper was numerous in Ontario and New Brunswick, causing much hopperburn on beans and potatoes. It was less numerous than usual in southern Quebec. It is probably the most serious pest of potatoes and beans in southern Ontario.

LEAF MINERS.—In British Columbia, the spinach leaf miner caused some damage in the Vernon and Lavington districts. In southern Alberta, the numbers on beets were the largest in several years. In southwestern Ontario it caused slight damage to spinach and beets, but in the Ottawa Valley it occurred in outbreak numbers, some plantings of spinach being almost a complete loss. Large numbers occurred also in southeastern Quebec, notably in the Montmagny and Quebec City areas.

MAGGOTS IN ONIONS.—The onion maggot was normally injurious in the lower Fraser Valley, B.C., but was scarcer than usual in the interior. In Saskatchewan, damage to onions on truck farms ranged from 60 to 80 per cent and in dry-land areas from 15 to 20 per cent. In Manitoba, an increase in numbers was reported from Winnipeg and damage to onion seedlings at Brandon was 5 per cent. In Ontario, damage ranged from moderate to severe where control materials were not applied, but was less than usual in southwestern areas. Infestations in southern Quebec were generally lighter than in 1956, although extensive damage occurred in the Quebec City area. In the interior of British Columbia, populations of *Eumerus strigatus* (Fall.) were also very small, even where no control measures had been used for five years. In Prince Edward Island and northeastern Nova Scotia, this bulb fly was found for the first time on rutabagas.

MEXICAN BEAN BEETLE.—In Ontario, light infestations caused slight damage in Middlesex, Huron, Lambton, and Kent counties. No infestations were found in Quebec.

BULB AND STEM NEMATODE.—Approximately 40 acres of onions in the Leamington area were destroyed by *Ditylenchus dipsaci* (Kuhn, 1857) Filipjev, 1936. This was the first occurrence of the pest in the onion-growing marshes of southwestern Ontario.

PEA LEAF WEEVIL.—This insect caused severe damage to seedling peas and minor damage to broad beans in the lower Fraser Valley, B.C.

PEA MOTH.—In British Columbia, the pea moth was again present but only in minor infestations. In Nova Scotia it continued to be scarce. In Prince Edward Island, moderate infestations occurred in gardens, but in commercial plantings damage to peas was less than one per cent.

PLANT BUGS.—Infestations of *Orthops scutellatus* Uhl. on some seed crops of carrots at Grand Forks, B.C., were the heaviest recorded since 1948. An unidentified species was present in smaller numbers. In southern Quebec, *Liocoris lineolaris* (Beauv.) was abundant early in the season; at Ste. Clothilde lettuce and Chinese cabbage in muck soil was extensively damaged. In Nova Scotia this species was more numerous than in 1956, and in Prince Edward Island it was numerous but caused little serious damage.

POTATO STEM BORER.—In southern Quebec, this borer fed on corn, potatoes, tomatoes and rhubarb. In New Brunswick it damaged corn in several localities and in Nova Scotia, where it occurred in the largest numbers in several years, it damaged newly set strawberries as well as the hosts indicated above.

ROOT MAGGOTS IN CRUCIFERS.—The cabbage maggot occurred in normal abundance in the lower Fraser Valley, B.C., and in Alberta. In southwestern Ontario, it caused little damage to early seedlings of cabbage and cauliflower, but was fairly numerous in radish. A few fields of turnips were spoiled for market purposes. In the Ottawa, Ont., area, it was the major pest of vegetable crops. Populations were the largest on record and oviposition was three and one-half times the average for the previous ten years. Losses in all crucifrous hosts were the most severe in several years and were accentuated by drought. In the Holland Marsh, Ont., the maggot was more abundant than in 1956 and caused moderate damage. In southern Quebec, damage was extensive and extended as far north as Blanc Sablon. At Ste. Clothilde, injury to radish was noted for the first time in the muck soils of the area. In New Brunswick, losses in early cabbage and cauliflower ranged from 60 to 100 per cent, the greatest in five years. In Nova Scotia the insect was abundant and poorly controlled. In Prince Edward Island it severely damaged untreated rutabagas and cabbage. In Newfoundland, damage to cabbage and cauliflower was light, but swede turnips were moderately to severely infested. In the interior of British Columbia, *Hylemya* spp. severely damaged turnips in many localities. In Saskatchewan *H. floralis* (Fall.) occurred in normal abundance. This applied also to Manitoba, but because of abundant moisture damage was below average. In New Brunswick, increased populations attacked most turnip crops. In Saskatchewan, *H. planipalpis* (Stein) caused above average damage to radish at Prince Albert. At Brandon, Man., it infested less than five per cent of the radish crop. In Prince Edward Island, *Coenosia tigrina* (F.) and *Scatophaga stercoraria* (L.), predators of the root maggot, were abundant in turnip fields.

SEED-CORN MAGGOT.—Soybeans at Altona, Man., were infested by this maggot. In the Chatham, Ont., area, for the first time in at least eight years, this insect was not recorded in a field-scale infestation, although moderate infestations occurred in experimental lots of beans and peas. At Harrow, Ont., a few acres of early beans had to be re-seeded. Only two generations occurred in the area in 1957. In southern Quebec, moderate to severe infestations were commonly reported. In Nova Scotia, sub-normal numbers were correlated with unusually dry weather. In Prince Edward Island, moderate to severe damage occurred in some corn and bean fields and in potato sets in sandy soil.

SLUGS.—In British Columbia, slugs caused commercial damage to tomatoes near Kamloops and were numerous in the Okanagana and Kootenay districts. In the Prairie Provinces, greatest damage was reported from Manitoba. In the Winnipeg area, damage to vegetables was the most severe on record. In Ontario, slugs were rated the most important garden pest and field damage to corn and timothy was common.

SPIDER MITES.—Heavy infestations were observed in two fields of tomatoes near Burlington, Ont. They had apparently developed on raspberries.

SQUASH BUG.—This pest occurred in moderate numbers on squash and pumpkin in southwestern and eastern Ontario. Observations during eight years indicate it to be a minor pest.

SQUASH VINE BORER.—Damage to squash and pumpkin was conspicuous by July in southwestern Ontario. Adults were more numerous than in any previous year.

TOMATO PSYLLID.—At Lethbridge, Alta., this insect occurred in the first summer infestation since severe outbreaks during 1936-1940.

THRIPS.—In Ontario, heavy rains held early infestations of the onion thrips to a minimum, but some large populations developed later on onions in the Erieu Marsh and the insect was unusually numerous on beans, cucurbits, and cabbage.

ZEBRA CATERPILLAR.—Not usually a serious pest, this insect occurred in outbreak numbers in Ontario. It was most numerous on turnips, causing severe local defoliation in both eastern and southwestern areas. Cabbage, carrots, beans, sugar beets, and many other hosts were attacked.

FRUIT INSECTS

APHIDS.—In British Columbia, *Aphis pomi* DeG. was present in injurious numbers in most apple orchards and nurseries. In Ontario it was scarce except in Essex and Kent counties, where it was abundant. In eastern Quebec it was scarce, but in southwestern Quebec it was more abundant than in 1956. In New Brunswick it was generally abundant, but in Nova Scotia small numbers caused only minor damage. In Newfoundland, epidemic numbers were reported. *Sappaphis roseus* (Baker) was of little economic importance in apple-growing areas from British Columbia to Nova Scotia, although some increase in damage was noted in the latter province. *Eriosoma lanigerum* (Hausm.) was well controlled in most British Columbia orchards by *Aphelinus mali* (Hald.). In Nova Scotia, too, it was scarce, but in southwestern Quebec was tending to increase. *Rhopalosiphum fitchii* complex occurred on apple in moderate numbers in Nova Scotia. *Myzus cerasi* (F.) was much less numerous than in 1956 in British Columbia and of little importance in Ontario, but in Newfoundland cultivated cherries were severely infested. *Hyalopterus pruni* (Geof.) was again scarce in British Columbia, but in the Niagara Peninsula, Ont., it caused severe damage in untreated plum orchards. In British Columbia, *Myzus persicae* (Sulz.) occurred in only a few peach orchards, as in 1956. Aphids caused moderate injury to currants from Saskatchewan east to Nova Scotia. *Aphis illinoisensis* Shimer, exceedingly scarce in the Niagara Peninsula, Ont., for 30 years, heavily infested grapes at two points in Lincoln County. In coastal British Columbia, *Myzus ascalonicus* Doncaster was of minor importance on strawberry, but *Pentatrichopus* (previously *Capitophorus*) *fragaefolii* (Ckll.) was abundant.

APPLE (AND BLUEBERRY) MAGGOT.—In Manitoba this insect does not attack apple, but small numbers were found on hawthorn. In Ontario damage to apples was below average, but infestation of prunes increased in the Niagara area. In Quebec small populations were reported. In New Brunswick and Nova Scotia, infestation of apple was generally lighter than in 1956, but in Prince Edward Island it was not so well controlled. Populations on blueberry were generally light in the Atlantic provinces.

APPLE MEALYBUG.—Although this insect was present in many orchards in New Brunswick and Nova Scotia, heavy infestations were found in only two orchards in the former province.

APPLE SEED CHALCID.—Apparently present on apple from Manitoba eastward, this insect was numerous on some varieties.

APPLE SUCKER.—This insect was more numerous than in 1956 in Nova Scotia and required control in some orchards.

BLUEBERRY SAWFLY.—This insect was scarce in New Brunswick, but was more numerous than in 1956 in Nova Scotia.

CANKERWORMS.—In Manitoba, a light infestation of the fall cankerworm occurred on apple at Morden. In Nova Scotia, this species was generally abundant, but the winter moth was more numerous in some orchards.

CHAIN-SPOTTED GEOMETER.—Several large bluberry barrens in Charlotte County, N.B., were severely damaged by this insect.

CHERRY FRUIT FLIES.—*Rhagoletis cingulata* (Loew) continued to be a major pest of cherry on southern Vancouver Island and it occurred also near Abbotsford, B.C. *Rhagoletis fausta* (O.S.) was a minor problem on Vancouver Island and was not reported in the Fraser Valley.

CICADAS.—In the interior of British Columbia, cicadas were much less injurious to fruit trees than in 1956.

CODLING MOTH.—In British Columbia, populations appeared to be increasing in the Okanagan and Similkameen valleys. As in 1956 in Ontario, numbers and injury remained at a low level, mainly because of weather conditions. However, a few heavy second-brood infestations developed on apple and there was a definite increase in damage to pear in the Niagara area. From Quebec east to Prince Edward Island, populations generally either remained at a low level or were further reduced. Infestation in Nova Scotia was about the lightest in 20 years. However, in all provinces there were scattered concentrations requiring control measures.

CRANBERRY FRUITWORM.—In Nova Scotia and Prince Edward Island, this insect was again scarce, damaging less than one per cent of the fruit.

CURCULIONIDS.—At Morden, Man., the plum curculio was abundant on plum and cherry. In Ontario, it was at its lowest ebb in several years. In Quebec populations were average to above average and in Nova Scotia they remained small. Only local occurrences of *Anthonomus signatus* Say were reported in Manitoba, Ontario, and Quebec, but in the Atlantic provinces a noticeable increase and serious damage occurred in most fields of strawberries and on wild hosts. Normal infestations of *Brachyrhinus ovatus* (L.) occurred in British Columbia. Minor numbers were noted at Dauphin and Morden, Man. Large numbers occurred in southern Quebec and, although reports in the Atlantic provinces were numerous, most of them involved the invasion of dwellings rather than damage to strawberries. *Brachyrhinus sulcatus* (F.) was abundant in the lower Fraser Valley, B.C., and *Sciopithes obscurus* Horn and *Nemocestes* sp. were collected on strawberry near Abbotsford. In Nova Scotia, other weevils damaging strawberry included *Barynotus obscurus* (F.), *Tropiphorus terricola* (Newm.), and *Trachyphloeus bifoveolatus* (Beck).

CURRANT BORER.—Occurrences were reported from Vernon and Creston, B.C., and Morden, Man.

CURRANT FRUIT FLY.—In Saskatchewan this insect was not reported, indicating a continued decline in numbers. In southern Manitoba it occurred commonly on currant and gooseberry.

EUROPEAN APPLE SAWFLY.—In British Columbia an increase in abundance occurred in the infested area, the only one in Canada.

EYE-SPOTTED BUD MOTH.—In British Columbia this bud moth continued to increase, causing moderate to severe injury to apple. In Ontario only a few light infestations were reported, but it continued to increase in the Georgian Bay area. Eastward through southern Quebec and the Atlantic provinces reports indicated consistently small populations and minor injury.

FRUIT TREE BORERS.—Scanty reports of the roundheaded apple tree borer indicated little damage. In British Columbia, the peach tree borer continued at a low ebb and in Ontario some increase occurred in the Niagara Peninsula, but damage was not severe. In southern Ontario the lesser peach tree borer continued to be a problem of increasing importance. In British Columbia the peach twig borer was a minor pest.

GRAPE BERRY MOTH.—Infestations in Ontario were generally light.

GREEN FRUITWORMS.—The cherry fruitworm was found for the first time at Summerland and Oliver, B.C. A light infestation of the lesser appleworm occurred at Morden, Man. In Nova Scotia, *Lithophane* spp., *Xylena* spp., and *Hedia variegana* (Hbn.) occurred on apple in small numbers.

IMPORTED CURRANTWORM.—From Saskatchewan eastward to Nova Scotia, infestation of currant and gooseberry was generally light. In Prince Edward Island and Newfoundland damage was severe.

LEAFHOPPERS.—On Lulu Island, B.C., populations of *Macropsis fuscula* (Zett.) on loganberry were drastically reduced by low temperatures in 1955. Since then they have increased rapidly on loganberry, wild cherry, and wild blackberry and have spread several miles to the east and south. A major build-up of the bramble leafhopper and the rose leafhopper also

occurred on cane fruits and strawberry in coastal regions. In the interior, leafhoppers were injurious to plum and prune. At Morden, Man., the potato leafhopper was abundant on apple. In Ontario the latter species was locally abundant at Port Rowan and in Nova Scotia it was rather less numerous than in 1956. The grape leafhopper continued to be very scarce in the Niagara Peninsula. Heavy infestations of an undetermined leafhopper damaged strawberry and lettuce in Norfolk County, Ont.

LEAF MINERS.—In New Brunswick, *Lithocolletis malimalifoliella* Braun caused some defoliation on apple in the Keswick Ridge and Woodstock districts and in Nova Scotia populations increased in some areas.

LEAF ROLLERS.—In the interior of British Columbia, the fruit tree leaf roller was even more abundant than in 1956, notably at Oliver, Osoyoos, and Creston. In southwestern Quebec severe damage was comparable to that of 1956. In Ontario the red-banded leaf roller occurred in probably the most severe infestations on record; second-generation larvae damaged peach, plum, and pear in Essex County. Damage in southwestern Quebec was not considered severe. The strawberry leaf roller occurred commonly in Manitoba and Ontario, but caused little damage. *Swammerdamia caesiella* Hbn., a recently introduced pest of Japanese plum, occurred in at least two-thirds of the orchards in the eastern half of the Niagara Peninsula and in a few in the western half. Larvae of *Pandemis limitata* (Rob.) fed on the fruit of apricot at Vineland and cherry at Grimsby, Ont. In Nova Scotia, control measures were necessary against the gray-banded leaf roller in some areas. Other leaf roller species remained scarce. In Newfoundland, *Cnephasia virgaureana* Tr. moderately infested strawberries.

MITES.—In the interior of British Columbia, the European red mite continued to cause serious injury in some orchards. In the Niagara Peninsula, Ont., it became abundant late in the season, especially on peach and plum. Infestations on apple were moderate to severe in the Province. In most orchards of southwestern Quebec it was well controlled. In New Brunswick, only a few orchards were seriously affected. In Nova Scotia, infestations were light to moderate in most orchards and in Prince Edward Island it was a problem in only two commercial orchards. In British Columbia, *Tetranychus telarius* (L.) caused early, medium infestations on raspberry and strawberry in coastal areas, but was later retarded by cool, wet weather. In the interior, infestations were lighter than in 1956. In Ontario and Quebec, medium to heavy infestations developed on apple and strawberry in many areas. In Nova Scotia, plantings of strawberries were most affected. In coastal British Columbia the cyclamen mite, *Steneotarsonemus pallidus* (Banks), caused severe local injury to Goldstream strawberries at Aldergrove and it was recorded for the first time at Creston in the Kootenay Valley, where it infested Northwest strawberries. In Manitoba, strawberries were not seriously infested. In Nova Scotia Sparkle strawberries were severely attacked. *Bryobia arborea* M. & A. was of little importance in British Columbia, but in Nova Scotia it was more abundant than the European red mite in many apple orchards. *Eriophyes* spp. were only minor pests in British Columbia and Manitoba. *E. pyri* (Pgst.) was common in Ontario and especially injurious in nursery stock. In Nova Scotia it occurred in small numbers on pear and apple. In Prince Edward Island it was numerous and injurious. Other mites of this group in Ontario included *Vasates fockeui* (Nal. & Trt.) on prunes and *Diptacus gigantorhynchus* (Nal.) on Japanese plum in the Niagara Peninsula. *Tetranychus canadensis* (McG.) was generally reported on peach in the Niagara Peninsula. In British Columbia, *T. medanieli* McG. was reported only in a few orchards and *Eotetranychus carpini borealis* (Ewing) remained at a very low ebb. In Saskatchewan, raspberries were commonly infested by undetermined mites.

ORIENTAL FRUIT MOTH.—In 1956 this insect was found in peaches imported from Washington State, U.S.A., into the Okanagan Valley, B.C. During 1957 every effort was made to eliminate possible survivors and extensive trapping yielded no moths. In Ontario, infestation of peaches was comparatively light in the Niagara Peninsula, but in Essex and Kent counties injury in poorly sprayed orchards was the greatest in several years.

PEAR PSYLLA.—In British Columbia, populations on pear in the Okanagan and Similkameen valleys remained at a low level. In Ontario, only a few infestations of importance were reported and in Nova Scotia light damage reflected about average abundance.

PEAR-SLUGS.—In coastal British Columbia, unusually large populations of the pear-slug caused considerable leaf and fruit injury on pear and cherry. In the interior, damage was light. In the Edmonton, Alta., area the insect was numerous. In Ontario and Quebec, populations were well controlled and in Prince Edward Island some severe damage was reported. In British Columbia, *Pristiphora californica* (Marl.) was at a low ebb.

PLANT BUGS.—The tarnished plant bug severely damaged strawberries in Manitoba, rendering unmarketable up to 25 per cent of the fruit in some gardens. In Ontario, damage to peach was minor although it had been severe in 1956. On apple in Nova Scotia, *Criocoris saliens* (Reut.) caused more damage to fruit than usual and *Campylomma verbasci* (Mey.) and *Lygus (Neolygus) communis novascotiensis* Kngt. were scarce. On strawberry, *Calocoris norvegicus* (Gmel.) was well controlled.

RASPBERRY BUD MOTH.—In the area about Belleisle, N.B., damage to buds of raspberry showed a further increase.

RASPBERRY CANE BORERS.—*Oberea* spp. were generally scarce in the adult stage in Eastern Canada and damage to cane tips was light. Second-year larvae were present in the old canes in normal numbers in most areas.

RASPBERRY CANE MAGGOT.—This pest was very abundant in commercial plantings of loganberry and raspberry on Vancouver Island and in the lower Fraser Valley, B.C. In some plantings as many as four-fifths of the new shoots were destroyed.

RASPBERRY FRUITWORMS.—In British Columbia, *Byturus bakeri* Barber occurred in light infestations on raspberry in the lower Fraser Valley, but in the Abbotsford area large populations were found on wild thimbleberry. *Byturus* sp. was reported from a few points in eastern Saskatchewan and in Manitoba it appeared to be spreading eastward from the Manitoba-Saskatchewan boundary.

RASPBERRY ROOT BORER.—This insect continued to be a serious pest of raspberry and loganberry in coastal areas of British Columbia and of raspberry in the interior. It was reported also from Fredericton, N.B.

RASPBERRY SAWFLY.—Light damage was reported at Prud'homme and Kindersley, Sask., and considerable damage at Morden, Man., and in eastern Ontario. The insect is fairly common, but as its damage usually has little effect on the crop it is not regularly reported.

SCALE INSECTS.—In all fruit-growing areas of the country, the oystershell scale caused negligible damage. However, in southwestern Quebec, a noticeable increase was observed for the second successive year. In the interior of British Columbia, *Lecanium* spp. continued to increase in numbers and caused the greatest injury to peach and apricot in the history of fruit growing in the area. *Pulvinaria* sp. was of minor importance. In Ontario, *L. corni* Bouché was abundant on Japanese plum and on peach in two orchards in the Niagara Peninsula. In the Brighton area it was increasingly common and especially injurious to Spy and Wealthy apples. In the interior of British Columbia, *Aspidiotus perniciosus* Comst. increased considerably in the Oliver-Osoyoos district and *A. ostreaeformis* Curt. continued to be unimportant. In the Victoria area, *L. coryli* (L.) was observed for the first time causing damage to holly. In Saskatchewan, *Chionaspis* sp. damaged apple at Rosetown. In Ontario, no heavy infestations of *Chionaspis* sp. were found on peach, although slight increases occurred in the Niagara Peninsula.

STINK BUGS.—In the Oliver-Osoyoos, B.C. area, *Chlorochroa ligata* (Say) was recorded injuring the fruit of peach for the first time in several years and at Hendon, Sask., *Sehirus cinctus* (P. de B.) damaged the fruit of raspberry.

TENT CATERPILLARS.—*Malacosoma* spp., reported for the first time since 1952 in Saskatchewan, caused the most severe damage on record in the Maple Creek area. In New Brunswick they caused no damage in orchards. Iu Nova Scotia *M. disstria* Hbn. was not reported, but *M. americanus* (F.) was fairly common on apple. In Prince Edward Island also it caused some damage. In New Brunswick, *Archips cerasivoranus* (Fitch) occurred in increased numbers on apple and wild cherry.

THRIPS.—In the interior of British Columbia, a small amount of "pansy spot", believed to be caused by *Frankliniella occidentalis* (Perg.), was observed in some orchards. In New Brunswick, *F. vaccinii* Morgan was more numerous than in 1956 in blueberry barrens in Charlotte County and in Nova Scotia it was present in all plantings, infestation varying from light to severe.

WHITE-MARKED TUSSOCK MOTH.—In New Brunswick, small infestations were found in orchards in the Moncton and Keswick Ridge areas. In Nova Scotia, too, populations on apple were small and on blueberry losses were minor by comparison with those of 1956.

PARASITES AND PREDATORS OF ORCHARD PESTS.—In southern Ontario the European mantis was fairly common, but populations of most other predators were small. In Nova Scotia, predators of apple pests continued an increase in numbers extending over the past few years. *Anthocoris musculus* (Say) showed the greatest increase and was generally plentiful in orchards on modified spray schedules. Most of the mirids also showed increases, but the predacious thrips *Haplothrips faurei* Hood was generally scarce. There were slight to moderate increases in some species of the pentatomids, coccinellids, chrysopids, and nabids. Typhlodromids were not quite as numerous as usual and *Anystis agilis* Banks was more abundant than usual. Spiders were present in about average numbers.

INSECTS AFFECTING GREENHOUSE AND ORNAMENTAL PLANTS

APHIDS.—Aphids were generally very abundant on almost all plants in the Prairie Provinces. Shade trees, especially Manitoba maple, and ornamental shrubs were particularly affected in southern areas of all three provinces. In southern areas of Ontario and Quebec, too, aphids were abundant, especially in flower gardens. In Prince Edward Island the balsam

woolly aphid continued to cause extensive damage to balsam, and in the St. John's, Nfld., area white pine was attacked by *Pineus strobi* (Htg.) and elm by *Colopha ulmicola* (Fitch).

BORING INSECTS.—In Manitoba the lilac borer and the columbine borer were reported. In southern Ontario the bronze birch borer killed the upper branches of white birch in the Chatham area and the iris borer was more numerous than usual.

BULB FLIES.—At Saanichton, B.C., 75 per cent of untreated daffodil bulbs planted in September, 1956, had their flower parts destroyed by August, 1957, by the narcissus bulb fly.

CURCULIONIDS.—The rose curculio was reported in varying abundance in Saskatchewan and Manitoba and acorn weevils, *Curculio* spp., were unusually numerous on oak and hazel in the area of Quebec City, Que.

LEAFHOPPERS.—The Virginia-creeper leafhopper caused the usual damage to Virginia creeper in Western Canada. The six-spotted leafhopper, in record outbreak numbers in the Prairie Provinces and Ontario, caused much damage to ornamentals; in southwestern Ontario, practically all asters were affected by aster yellows.

LEAF MINERS.—The lilac leaf miner was generally abundant and evidently more injurious than usual in Eastern Canada. In the west it caused severe local damage to lilac in Lethbridge, Alta., the first record in the southern part of the Province. In the interior of British Columbia, *Phyllocnistis populiella* Chamb. damaged most aspen in the Cariboo, South Thompson, Okanagan, and Kootenay areas. In southwestern Ontario, the birch leaf miner greatly disfigured young white birch, and in eastern Ontario the basswood leaf miner was at the highest population level in many years, 50 per cent defoliation of basswood being common in Hastings County.

LEAF ROLLERS.—Leaf-rolling caterpillars were common on poplar in the Prairie Provinces. In Alberta they occurred to the northerly limits of the Province and on to Ft. Simpson, N.W.T. In Manitoba *Archips conflictanus* (Wlk.) occurred in the interlake and Riding Mountain areas in one of the most serious and widespread outbreaks on record. In the Alonzo, Man., area *Sciaphila duplex* (Wlshm.) was abundant.

MITES.—In the Prairie Provinces mites in general were less abundant than usual on ornamentals, although the cyclamen mite was present in normal numbers in Manitoba. In southwestern Ontario the spruce spider mite was common on spruce and the maple bladder-gall mite was less numerous than usual. Elsewhere in the Province the latter species was numerous in some areas. In eastern Quebec, the two-spotted mite was numerous after a notable scarcity in 1956.

NORTHERN CORN ROOTWORM.—This insect fed on a wide range of flowers in southwestern Ontario.

PEAR-SLUG.—In Manitoba, cotoneaster and plum were less severely attacked than in 1956. In southern Quebec, populations on hawthorn and chokecherry were large.

PLANT BUGS.—Records of occurrence of the boxelder bug were conspicuously absent or extremely scarce in all reports received. A stink bug, *Cosmopepla bimaculata* (Thos.), damaged columbine in Kindersley and Saskatoon, Sask. The ash plant bug heavily infested ash trees at Morden, Man., and the four-lined plant bug damaged flowers at Chatham, Ont.

SAWFLIES.—The red-headed pine sawfly was generally reported in light infestations in eastern Ontario. The curled rose sawfly severely attacked rose at St. Jean, Que. *Trichiocampus viminalis* (Fall.) heavily infested poplar in Quebec City, Que., and the mountain-ash sawfly was a common pest of ornamental mountain ash in Prince Edward Island.

SATIN MOTH.—Populations in southeastern Quebec were again small and in Newfoundland were noticeably smaller than in 1956.

SCALE INSECTS.—In Manitoba the pine needle scale was slightly less abundant than in 1956. In southwestern Ontario the juniper scale was again abundant on ornamental evergreens, and in Prince Edward Island the oystershell scale was common on some ornamentals.

SPRUCE BUDWORM.—Populations on ornamental spruce were relatively small in Ontario and Quebec, but in Prince Edward Island severe damage was fairly common.

TENT CATERPILLARS AND WEBWORMS.—In the lower Fraser Valley, B.C., populations of *Malacosoma disstria* Hbn. and *M. pluviale* (Dyar) were at a low ebb. In southern Alberta the former species was very common. In Eastern Canada *M. disstria* and *M. americanum* (F.) were generally very scarce. In Manitoba *Hyphantria cunea* (Drury) was scarce and in eastern Ontario it occurred in light to moderate infestations. In southern Quebec *Archips cerasivoranus* (Fitch) occurred in light but widespread infestations.

THRIPS.—In Saskatchewan the gladiolus thrips was reported from Lancer and Tisdale and in Ontario is infested nearly all untreated plantings severely.

WILLOW LEAF BEETLES.—*Galerucella decora* (Say) was general throughout western Manitoba. In Ontario, *Plagiodera versicolora* (Laich.) was probably more numerous than ever before on ornamental willow and at St. Jean, Que., populations were large.

MISCELLANEOUS.—In British Columbia, a flea beetle, *Altica* sp. severely damaged poplar at Canoe and in the Kalamalka beach area. In Alberta, a stonefly, *Brachyptera pacifica* (Banks), in an unusual occurrence, defoliated boxelder and poplar in the Fort Macleod district. *Operophtera bruceata* (Hulst) severely defoliated poplar west of Claresholm and Nanton. *Hyalophora cecropia* (L.) occurred in outbreak proportions on Manitoba maple in the Taber area and *Halisidota maculata* (Harr.) and *Orgyia* (=*Notolophus*) *antiqua* (L.) were common on garden trees and shrubs in northern Alberta. *Alsophila pometaria* (Harr.) caused considerable defoliation of ornamentals and windbreaks in western Manitoba. *Colopha ulmicola* (Fitch) occurred on elm in southwestern Ontario in the largest numbers in several years. *Rhabdophaga strobiloides* (Walsh) was common on heart-leafed willow in eastern Quebec and *Porthetria dispar* (L.) was found in a few local infestations at Clarenceville, Que.

INSECTS ATTACKING MAN AND OTHER ANIMALS

BED BUG.—Infestations of the bed bug were reported from Vancouver, Kamloops, and Vernon, B.C.; Fort MacLeod, Bassano, Leduc, Wainwright, and Edmonton, Alta.; several unnamed localities in Saskatchewan; Winnipeg and Brandon, Man.; Ottawa (10 infestations), Almonte, Marmora, and Ohsweken, Ont.; Montreal and Hull, Que.; and several unspecified localities in Prince Edward Island.

BITING MIDGES.—*Culicoides* spp. caused some annoyance to humans in British Columbia and Prince Edward Island.

BLACK FLIES.—Below normal populations were reported from British Columbia, Saskatchewan, Manitoba, and Ontario.

BLACK WIDOW SPIDER.—Specimens from the Vernon, B.C., area constituted an unusual occurrence.

BLOW FLIES AND FLESH FLIES.—A case of dermal myiasis in a child occurred in northern Alberta, and *Phaenicia sericata* (Meig.) continued to cause myiasis among sheep at Bell Island, Nfld.

CATTLE GRUBS.—In the interior of British Columbia, populations appeared to be smaller than in recent years. In southern Alberta, warble flies emerged about ten days earlier than in 1956. In Manitoba, normal abundance was reported. In Ontario, organized control campaigns greatly reduced infestation in most beef and dairy farm areas.

FLEAS.—As usual, *Ctenocephalides* spp. commonly infested household pets from coast to coast and occasionally attacked humans, especially after vacation absences from dwellings. An infestation of the human flea, *Pulex irritans* L., was found in a dwelling at Saskatoon, Sask.

LICE.—Reports received at Vernon, B.C., indicated severe louse infestations on cattle in interior and coastal regions of the Province. In Manitoba, improved condition in most cattle was accompanied by smaller louse populations. *Phthirus pubis* (L.) was reported on two occasions at Edmonton, Alta., and one at Saskatoon, Sask. *Polyplax spinulosa* (Burm.) was taken on a laboratory white rat at Edmonton.

MOSQUITOES.—In British Columbia, early-season emergence was heavy, but the adults were short-lived, probably because of adverse weather conditions. Flood-water species emerged late and were not unduly troublesome. At Brooks, Alta., *Aedes melanimon* Dyar was taken for the first time in Canada. At Saskatoon, Sask., *Anopheles earlei* Varg. emerged in large numbers but other species were less numerous than usual. Greater Winnipeg, Man., was relatively free from mosquitoes as a result of an effective control program, but in rural areas populations were large and troublecome. In eastern Ontario, adults appeared late in smaller numbers than in 1956 and did not persist for long. In Prince Edward Island most species were more abundant than usual and persisted throughout the summer. In Newfoundland they were numerous, but less abundant than in 1956.

SNIPE FLIES.—*Symphoromyia* spp. were present in large numbers in the mountains in coastal areas of British Columbia.

TABANIDS.—In eastern Ontario, *Tabanus* spp. were much less numerous than in 1955 and 1956 and *Chrysops* spp. were only moderately abundant.

TICKS.—In British Columbia, *Dermacentor andersoni* Stiles was exceptionally numerous in the Kamloops-Nicola area. Localities once heavily infested, but relatively free of the ticks in 1957, included Rayleigh, Rosehill, and McCullough in the Kelowna area. At Merritt a herd of 300 cattle that had been relatively free of infestation for three years became heavily infested; ten were paralyzed and three died. Near Stump Lake, 32 yearlings in a herd of 118 were paralyzed and seven died. Near Nicola, 320 animals in a herd of 700 were paralyzed and about 30 died. Smaller outbreaks and losses occurred in herds at Merritt, Valleyview, Heffly, Ewing's Landing, and Quilchena. A child and two adults were paralyzed but recovered on removal of the ticks. As a result of increased surveys, the ear tick, *Otobius megnini* (Dugès), was found to be more widely distributed than previously supposed. Three herds of cattle a Adams Lake were 80 to 100 per cent infested. Infestation of deer at Lumby reached 75 per cent and

at Ewing's Landing 60 per cent. Mountain goats and sheep were generally heavily infested in the southern part of the Province. In Alberta, *D. andersoni* attached to humans at Calgary and Red Deer. *D. albipictus* (Pack.) was removed from a child at Edmonton and was abundant on moose in the Province. In Saskatchewan it occurred at Long Creek, St. Hubert, and Woodwater on horses, dogs, and man. *D. variabilis* (Say) was taken on man at Tantallon, Sask., and in Manitoba it was somewhat less abundant than in 1956. At Ottawa, Ont. *Ixodes cookei* Pack. was taken on a child, and the brown dog tick, *Rhipicephalus sanguineus* (Latr.), infested a dwelling as well as the dog housed therein.

HOUSEHOLD INSECTS

ANTS.—Ants of various species continued to be troublesome pests in dwellings, lawns, and gardens in all provinces. *Monomorium pharaonis* (L.) was widely reported in Eastern Canada and was apparently increasing as a persistent indoor pest.

BAGWORMS.—*Solenobia* sp. invaded a house in nuisance numbers at Beaurepaire, Que.

BOOKLOUSE.—In Prince George, B.C., the booklouse occurred in large numbers in a new house. In Alberta it infested a dwelling at Hairy Hill and an animal laboratory at Edmonton. At Windsor Mills, Que., it severely infested the section of a paper mill in which cardboard boxes were glued.

BOXELDER BUG.—Reports of this usually abundant household pest were extremely scarce in all provinces.

CARPET BEETLES.—*Attagenus piceus* (Oliv.) was the most common carpet beetle species and the most common household pest across Canada excepting coastal areas, where it was less numerous. It occurred mainly in dwellings and, although causing much over-all damage to fabrics, its activities were in many cases restricted mainly to accumulations of debris. *Anthrenus scrophulariae* (L.) was numerous in coastal areas and occasionally reported in Ontario and Quebec. *A. verbasci* (L.) was believed to be the most numerous species in Vancouver, B.C., but a single report from Toronto, Ont., was the only other record.

CLOTHES MOTHS.--Both species were fairly common in all provinces, but as they are rather readily recognized it is believed that most occurrences are unreported. In Prince Edward Island, *Tineola bisselliella* (Hum.) was reported more often than *Tinea pellionella* (L.).

CLUSTER FLY.—Hibernating adults were reported from Ottawa, Agincourt, Holland Landing, Waterloo, Stittsville, and Ingleside, Ont.; and Cantley, Que.

COCKROACHES.—The German cockroach was commonly reported in all provinces. At Louisburg, N.S., the species was a problem in fish-processing plants. The brown-banded roach, *Supella supellestilium* (Serv.), was again recorded in Edmonton, Alta., and in Ottawa, Ont. In Kingston, Brockville, Belleville and Smiths Falls Ont., its presence was recorded for the first time. In southern Quebec, the oriental cockroach, *Blatta orientalis* L., was recorded on several occasions.

CRICKETS.—Scattered reports of *Ceuthophilus* spp., mainly in basements, were received from the Prairie Provinces, Ontario, and Quebec.

EUROPEAN EARWIG.—A noticeable reduction in numbers was noted in St. Johns, Nfld.

FRUIT FLIES.—*Drosophila funebris* (F.) was numerous in several houses in Edmonton, Alta., and *D. busckii* Coq. occurred at St. Henri de Taillon, Que., a northerly record in Eastern Canada.

GROUND BEETLES.—Basement infestations included *Stenolophus conjunctus* (Say) at St. Hubert, Sask.; *Deleaster dichrous* (Grav.) in Ottawa and Trenton, Ont.; *Harpalus erraticus* Say in Lachute, Que.; and *H. rufipes* (DeG.) at several points in Prince Edward Island.

HOUSE FLY.—This pest was fairly well controlled in most homes, but was present in large numbers in many stables.

LARDER BEETLE.—Extensive infestations were reported from Edmonton, Alta.; Ottawa, Smiths Falls, Brockville, and Garfield, Ont.; Magog, St. Jean, and other points in Quebec; and in the Atlantic provinces.

MITES.—The clover mite was conspicuous by its scarcity as a pest in dwellings in all province.

MILLIPEDES.—These diplopods were again commonly reported as pests of human habitations in Ottawa.

Musca autumnalis DeG.—This recently introduced muscid was recorded from Bedford, Que., and from several points on Prince Edward Island, first records for both provinces.

SILVERFISH.—Silverfish were widely reported. At Ottawa they continued to be numerous in dwellings and apartments, especially new buildings.

STRAWBERRY ROOT WEEVIL.—This outdoor pest continued to invade dwellings, notably in Saskatchewan, Ontario, Quebec, Nova Scotia, and Prince Edward Island.

TERMITES.—At Kamloops, B.C., *Reticulitermes hesperus* Banks infested two dwellings, a basement apartment, and a fence post. In Toronto, Ont., *R. flavipes* (Koll.) continued to spread.

WOOD BORERS.—Powder-post beetles, not identified, were occasionally reported damaging buildings and furniture in western British Columbia, southern Ontario, and Prince Edward Island. *Xylotrechus undulatus* (Say), emerging from spruce lumber in a new dwelling at Fahler, Alta., caused some concern.

STORED PRODUCT INSECTS

STORED GRAIN INSECTS.—In terminal elevators at Vancouver, B.C., the insects most frequently encountered were the two moths *Hofmannophila pseudospretella* (Staint.) and *Endrosis sarcitrella* (L.). Other pests, usually occurring in small numbers, included the yellow mealworm, the spider beetle *Ptinus ocellus* Brown, mites, psocids, the granary weevil, and the black carpet beetle. In the Prairie Provinces, stored grain insects caused considerable concern because of the large quantities of grain stored on farms and in elevators, some of it in storage for five years or longer. On the basis of samples received from grain companies, farmers, and other sources in Saskatchewan and Manitoba, the following pests occurred in the percentages of the samples indicated: grain mites, 43.7; rusty grain beetle, *Cryptolestes ferrugineus* (Steph.), 35.4; fungus beetles, *Cryptophagus* spp., 20.8; hairy spider beetle, *P. villiger* (Reit.), 16.6; psocids, 14.5; foreign grain beetle, *Ahasverus advena* (Waltl.), 10.4. Others less frequently encountered included the meal moth, *Pyralis farinalis* (L.); red flour beetle, *Tribolium castaneum* (Hbst.); larder beetle, *Dermestes lardarius* L., yellow mealworm, *Tenebrio molitor* L.;*Lathridius minutus* (L.); *Anthicus floralis* (L.); *Typhaea stercorea* (L.); and, in large numbers, the hymenopterus parasite *Cephalonomia waterstoni* Gahan, associated with infestations of *C. ferrugineus.*

MILL AND WAREHOUSE INSECTS.—In British Columbia the most common pest in the interior was the black carpet beetle, *Attagenus piceus* (Oliv.). The most common spider beetle on the coast was *Ptinus ocellus*. Other pests that were fairly common included the larder beetle, the yellow mealworm, the moth *Hofmannophila pseudospretella,* the Mediterranean flour moth, the Indian-meal moth, the meal moth, and the confused flour beetle. The following species were encountered on fewer occasions: saw-toothed grain beetle, rusty grain beetle, granary weevil, varied carpet beetle, golden spider beetle, cadelle, *Endrosis sarcitrella* (L.), *Aphomia gularis* (Zell.), and mites. *Trogoderma simplex* Jayne was recorded in a cereal in Kelowna, and *Trigonogenius globulus* Sol. was recorded from Vancouver and Victoria. In a survey of flour mills, flour storages, and feed manufacturing plants in the Prairie Provinces, dermestid beetles were found to be particularly abundant. In some flour mills, *Cryptolestes* spp. and *Trogoderma* spp. were widely distributed in severe infestations, *Tribolium confusum* Duv. and *Tenebrio molitor* occurred commonly, but not in any severe infestations. Less frequently encountered were the cadelle, the larder beetle, the granary weevil, the hairy spider beetle, the webbing clothes moth, the saw-toothed grain beetle, *Cryptolestes turcicus* Grouv., *Trogoderma glabrum* (Hbst.), *T. inclusum* Lec., *Tribolium madens* (Charp.), *T. destructor* Uytten, and *Ptinus raptor* Sturm.

FOOD-INFESTING INSECTS.—Food in stores and dwellings was attacked by a great variety of pests. Reports from British Columbia included the drug-store beetle, the Indian-meal moth, the saw-toothed grain beetle, a spider beetle *(Ptinus ocellus),* silverfish, and *Tribolium* spp. Those in the Prairie Provinces included the drug-store beetle, the larder beetle, the saw-toothed grain beetle, spider beetles, the Indian-meal moth, *Tribolium* spp., and *Trogoderma sinistrum* Fall occurred in wheat in a granary at Bawlf. Principal pests in Eastern Canada were the saw-toothed grain beetle, the Indian-meal moth, the confused flour beetle, the cigarette beetle, the bean weevil, spider beetles, and the drug-store beetle.

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V. THE SOCIETY

PROCEEDINGS OF THE NINETY-FOURTH ANNUAL MEETING OF THE ENTOMOLOGICAL SOCIETY OF ONTARIO

24 - 26 October, 1957

The 9th Annual Meeting of the Entomological Society of Ontario was held in the Old Arts Building, Queen's University, Kingston, Ontario on the 24th, 25th and 26th of October 1957.

The meeting was opened by the President, Dr. A. S. West at 10:00 a.m. Thursday, 24th October, 1957.

The President introduced Dr. R. O. Earl, Dean, Faculty of Arts, Queen's University who welcomed the Society to the University. A very fine film entitled "Queen's University" was shown after which the President, at the request of the members present named the following nominations committee.

J. McB. Cameron—*Chairman*
H. W. Goble
H. G. James

The meeting then proceeded as per programme.

The annual business meeting was held at 11:00 a.m. Friday, 25 October 1957. On a motion by Messrs. Oakley and Begg the minutes of the previous meeting were adopted as read.

The financial statement for the year ending 18 October, 1957 was presented by the Secretary-Treasurer. On a motion by Messrs. Allan and Copeland the statement was approved by the members.

The President outlined the operation of a mail ballot as had been discussed at the last meeting and on a motion by Messrs. McNally and Cameron the members voted to have this procedure put into effect at once.

The President then explained the state of the Society finances and pointed out that during the past years the available cash balance was dwindling alarmingly. He stated that if it was the wish of the members to have a strong worthwhile Sociey the following points must be considered.

1. Cut down expenses.
2. Increase in dues.
3. Increase in registration fees at meetings.
4. Reduction of grant to Entomological Society of Canada.

After some discussion it was unanimously decided on a motion by Messrs. Dustan and Boyce that the membership fee of the Entomological Society of Ontario be set at Six Dollars as of 1st January, 1958.

The President explained that the present Board of Directors had agreed to pass on a suggestion to the new Board that the annual grant to the Entomological Society of Canada be reduced.

The question of a change in time of meeting was brought up and it was decided that any change from the present arrangement would not be desirable.

The President then asked for the report of the Nominations Committee. The chairman reported as follows:

Directorate

T. Burnett, Belleville
G. S. Cooper, Toronto
D. M. Davies, Hamilton
G. G. Dustan, Vineland Station
L. L. Reed, Ottawa
J. B. Thomas, Sault Ste. Marie
A. G. McNally, Guelph

Auditors

R. G. Cooke, Guelph
C. J. Payton, Guelph

Moved and seconded by Messrs. Ross and Goble that nominations close.—Carried.

The President then announced that the next annual meeting would be a joint meeting with the Entomological Society of Canada during the last week of October 1958 in Guelph.

F. W. Fletcher informed the chair that he had been instructed to invite the Society to meet with the Entomological Society of America during the first week of December 1959 in Detroit.

The President accepted on behalf of the Society and asked that Dr. Fletcher convey the thanks and acceptance of this Society to the Entomological Society of America.

A discussion took place in which many members expressed their views concerning the two publications — The Canadian Entomologist and Annual Report. It was felt that the publications committee does not function and that the members had very little knowledge of the publication policy. The possibility of financing another publication was raised. Messrs. Ross, West and Cameron reviewed the original plan for joint publication between the Ontario and the National Societies. It was also brought out that in the past the publications committee had found it impossible to operate. Dr. Chant expressed concern at the time necessary to publish the Annual Report. Dr. House stated that papers, which he felt should go into the Canadian Entomologist, were going into other journals and this had caused the Canadian Entomologist to become drab. He put forward the proposal that, owing to the large number of entomologists producing papers, the number of pages in each issue of the Canadian Entomologist should be increased. Dr. Cameron stated that he thought the time required to have an article printed in the Canadian Entomologist was well within reason.

The discussion ended with a motion by Messrs. Shewell and Heimpel that:—

"the Publications Committee of the Entomological Society of Ontario submit a report at the next annual meeting of the Society setting out the long term policy of both the Canadian Entomologist and the Annual Report." Carried.

Messrs. Boyce and House moved that the Society express its approval and satisfaction of the work done by the Editor of the Annual Report. Carried.

The President informed the meeting that the Society membership had increased by eighteen during the past year and that this increase was due, in the most part, to the fine efforts of Messrs. Baker and Ross. He also thanked the members for the support which had been given him during the past year when it had been his privilege and honour to be president of the Society.

The business meeting then adjourned at 12:30 P.M.

On Friday, 25 October, 1957, a delightful dinner was served at the British American Hotel, Kingston and Mr. Paul Provencher of North Shore Paper Company, Montreal, gave an address.

Paper reading concluded the next day and the 94th annual meeting was brought to a close at 11:36 a.m. Saturday, 16 October by the President for the 1957-58 season, G. G. Dustan of Vineland Station.

W. C. Allan,
Secretary-Treasurer.

ENTOMOLOGICAL SOCIETY OF ONTARIO
GUELPH - CANADA

FINANCIAL STATEMENT
1956-57

RECEIPTS

1. Dues	$1,029.10
2. Back Numbers	15.75
3. Grant	300.00
4. Interest	42.00
	$1,386.85
Bank Balance Oct. 31, 1956	409.83
	$1,796.68
Bonds October 31, 1956	$ 400.00

EXPENDITURES

1. Dues to Ent. Soc. Can.	$ 860.00
2. Grant to Ent. Soc. Can.	250.00
3. Exchange	3.17
4. Library	157.65
5. Postage	99.50
6. Envelopes	27.13
7. Stenographic Work	10.00
8. Annual Meeting 1956	5.00
9. Auditing	5.00
10. Telegrams	1.00
11. Programme Committee	2.00
12. Receipt Pads	1.20
	$1,421.65
Bank Balance Oct. 18, 1957	407.03
	$1,828.68
Less O.S. Cheque	32.00
	$1,796.68
Bonds October 18, 1957	$ 400.00

Auditors

R. C. Cooke
C. J. Payton

W. C. Allan,
Secretary-Treasurer
18 October 1957.

VI. INDEX

INDEX

It is believed that all well-known species mentioned in Sections I, II & III are listed here. Others may be found by referring to the crop, the habitat or the locality, in the text or index.

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ANNUAL REPORT
OF THE ENTOMOLOGICAL SOCIETY OF ONTARIO

AUTHORS' GUIDE

1. Authors should refer to papers in this volume for guidance on arrangement of material. Manuscripts should be typed double spaced on paper 8½ x 11. Main headings by the left hand margin, in capitals, subsidiary headings in italics.

2. Statements in the text that require confirmation by reference to other work should be written so that they are followed by a number (in brackets) which should be the number attached to the reference in "Literature Cited."

3. In order to make the "Literature Cited" of maximum possible benefit to entomologists in many parts of the world to which the Annual Report is sent, references should be listed alphabetically as follows:

Reference number in brackets, surname of author in capitals, initials of author, date in brackets, full title of paper as given by the author, a dash, name of the journal abbreviated according to the system adopted in the "World List of Scientific Periodicals," volume number underlined, colon, number of the first page of the article, period.

Books should be listed as: Reference number, author, date, title, edition, publisher, place of publication.

For example the text of a paper may contain a statement like "many people find cockroaches repugnant (14)", or "Doe (14) claims that cockroaches are repugnant to many."

"Literature Cited" for this reference should be:
(14). DOE, J. (1888) Some observations on cockroaches in houses.—Bull. ent. Soc. Guelph 5: 46.

4. In order to avoid embarrassment to the Society and the editor, authors describing work done under Government sponsorship are asked to get their local most senior officer to certify that the paper has been passed for publication.

5. Material accepted for publication in the Annual Report normally should not have been and should not subsequently be published elsewhere.

6. All organisms should be supplied with scientific name and authority.

7. All chemical compounds should be given their chemical or commonly accepted name and must not be referred to by trade names.

8. Contributions should be submitted to the Editor, Annual Report of the Entomological Society of Ontario, Entomology and Zoology Department, Ontario Agricultural College, Guelph.

Insects

ANNUAL REPORT of the ENTOMOLOGICAL SOCIETY OF ONTARIO

Volume Eighty-Nine

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(Published October, 1959)

PUBLISHED BY AUTHORITY OF
THE HONOURABLE WILLIAM A. GOODFELLOW, MINISTER OF AGRICULTURE FOR ONTARIO

ENTOMOLOGICAL SOCIETY OF ONTARIO
1958 - 1959

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Correspondence about membership in the Society, or exchange of publications, should be addressed to the Secretary-Treasurer, Entomological Society of Ontario, Ontario Agricultural College, Guelph, Ontario.

ANNUAL REPORT
of the
ENTOMOLOGICAL SOCIETY OF ONTARIO

Volume Eighty-Nine

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HONOURABLE WILLIAM A. GOODFELLOW
Minister of Agriculture for Ontario

D. G. Peterson, *Editor*
P.O. Box 248, Guelph, Ontario

The Ninety-Fifth Annual Meeting of the Society was held with the Eighth Annual Meeting of the Entomological Society of Canada at the Ontario Agricultural College, Guelph, Ontario, October 29 - November 1, 1958.

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VI. THE SOCIETY

I. INVITATION PAPER

THE STUDY OF SOIL ARTHROPODS[1]

D. KEITH MCE. KEVAN

It is just over twenty-one years since the first and only previous occasion on which I visited Guelph. This was my first, very amateurish, contact with entomology in Canada, and so I take especial pleasure in making my official début with the Entomological Societies of Canada and Ontario at Guelph. May I, therefore, thank you through your respective Presidents and Executives for the signal honour you have done me in inviting me to address you here.

When I was first asked to give this talk, I had not realized that it was to be an opening address, but the subject I had in mind seemed to be suitable for the occasion, and there are several reasons why, in any event, I should probably have selected as my topic, the study of soil arthropods.

Firstly: Because the subject might conceivably interest a fairly large section of those present on account of the diversity of problems which such study involves.

Secondly: Because the subject interests me personally, although I cannot lay claim to any particular expertise in the field.

Thirdly: Soil arthropods have been much neglected until recently, and general interest needs stimulating, especially in North America – much of what knowledge we have of Canadian soil micro-arthropods, for instance, we owe, not to Canadians, nor even to Americans, but to Danes like Dr. Marie Hammer.

Fourthly: Because, in spite of the last remarks, at least two Canadian entomologists (neither of Canadian origin, I fear) have had something to do with the early development of soil arthropod studies; these were my old teacher at Edinburgh, the late Dr. A. E. Cameron who, as long ago as 1913, before he came to Canada as Professor of Zoology at Saskatoon, made a pioneer study of the effect of moisture on the soil insect fauna, and Dr. (now the Rev.) K. M. King, also formerly of Saskatoon, whose advice regarding sampling and the collection of data, published before the present interest in the soil fauna had been properly aroused, is still sound today.

My last reason for talking about the soil arthropods is that, currently, the study of the soil fauna, as an entity, is a comparatively new field which is beginning to receive increasing attention, especially in Europe. Soil zoology has just learned to stand on its own feet; it has just stepped over the threshold from infancy to adolescence, and has at last set foot on the road which will lead to the long climb to adulthood; it is only now beginning to emerge from the preparatory pupal state to attain full imaginal stature among the other branches of zoology.

THE PATTERN OF RESEARCH

Perhaps, before proceeding further, we should stop and consider what is meant by the "soil fauna". A definition is not easy. Obviously if the widest interpretation is accepted then a very substantial proportion of all terrestrial arthropods would have some claim to be included, if only for indirect reasons. It would be impractical also to restrict the term to those species which live exclusively underground since a great number of important species spend much of their lives above the surface. We must, therefore, include besides those species which spend their whole lives in the soil, animals which pass one or more of

[1]Contribution from the Faculty of Agriculture, McGill University, Macdonald College, Quebec, Canada; presented as an invitation paper to the 95th annual meeting of the Society and the 8th annual meeting of the Entomological Society of Canada, Guelph, Ontario, October, 1958. JOURNAL SERIES NO. 433.

their *active* developmental stage underground; it is preferable to exclude species which use the soil only for hibernation, oviposition or pupation. "Soil", from a biological standpoint, is the substrate in which plants may take root, and includes both mineral matter and the dead organic material mixed with it, or lying on top of it. There is, of course, a transition from the humus layers below to the freshly accumulated litter above, and it is impractical to differentiate sharply between the true soil fauna and that of the litter. Those who study the soil fauna must study both.

It is difficult also to divorce the study of soil arthropods from that of other soil animals, but, since arthropods, numerically at least, constitute the greater part of the air-breathing fauna of soil and litter, we can conveniently treat them separately. (Tardigrades, for present purposes, are not considered to be arthropods!). It is impossible to treat the insects separately, however, for enormous though their numbers may be, they definitely take second place among the soil arthropods—or third place if one adopts the view that collembola are not insects. Mites are undoubtedly the most abundant soil arthropods, and, together with collembola they dominate the subterranean scene.

All branches of field biology (and the study of soil arthropods is basically a field study) go through a series of "stadia" before settling down to become mature disciplines, usually beginning with a descriptive phase. The study of soil arthropods, however, has followed a somewhat different course from the usual, and synecological research became predominant before much of the fauna making up the populations studied could be accurately determined. Seldom during this synecological phase, which is still in progress, has much knowledge of biology or adequate understanding of morphology been gained. The investigation of life-histories has been limited to incidental studies of relatively few spectacular, unusual, or economically important species of insects, and, more recently, of certain medically important trombidiid mites which pass part of their lives in the soil. The biology of the most abundant soil arthropods has, for the most part, been neglected, and details of the life-history of scarcely a single euedaphic collembolan or mite are known, while the identification even of adults of many soil arthropods is uncertain. The identities of immature stages are mostly quite unknown.

Preoccupation with population studies has led to a great increase in research on methods of collection and extraction of a higher and higher proportion of the total arthropod fauna, so that, up to the present, probably more research time has been spent on attempting to perfect such techniques than has been spent on investigating the animals themselves. These investigations of methods are essential, and many previously unknown species have been discovered to be common by such means. It would seem, however, that there is an enormous amount of room left for increasing our knowledge of the systematics and biology of even the commonest animals that are caught by these, often elaborate, methods.

Detailed morphological studies of soil arthopods have been mostly confined to large or unusual species. Perhaps the most generally interesting and among the most comprehensive of these studies are those on the functional morphology of myriapods (essentially soil and litter-inhabiting creatures), principally by Dr. S. M. Manton of University College, London. Professor M. S. Gilyarov of Moscow has also deduced much regarding insect evolution from a study of the gross morphology of soil-inhabiting arthropods. His conclusions, although they may be controversial, are nevertheless stimulating. Physiological and autecological studies relating to the soil fauna are only just beginning to receive attention from such research workers as Mr. A. Macfadyen of Swansea and Dr. P. W. Murphy, now at Nottingham.

TEACHING

In spite of the fact that soil is so readily available, it is surprising how little attention has been paid to it in our centres of zoological and entomological learning. Fresh-water and marine littoral studies have reached the stage where almost every general biology course has something to do with one or other, or both (at least in theory!), but the soil, with its rich, if "difficult", fauna has remained virtually untouched for instructional as well as research purposes. Many students of zoology are familiar with quite obscure groups of marine animals, but have scarcely heard of some of the common soil animals such as Symphyla and Protura. I know of only one institution at which undergraduates have a full course of study on the soil fauna as such (viz. at the University of Nottingham School of Agriculture), but I hope in the near future to introduce a limited amount of instruction in soil zoology to entomology option undergraduates at Macdonald College (McGill University).

HISTORICAL

Various fairly reliable observations on larger soil arthropods, such as Gilbert White's account of the mole cricket written in 1770, have, of course, been published since early times. These were, however, not studies of the soil fauna *per se*, but, rather, of interesting animals which happened to live in soil.

Perhaps the first serious attempt to ascribe some importance to soil arthropods, and to recognize their existence as a vital force in the soil, was published in 1879 by the Danish forest pedologist P. E. Müller, who recognized the possible role played by "insects" in the development of forest soils. Forest biologists have been to the fore in the study of the soil fauna ever since, partly because the forest environment remains relatively stable, permitting soil micro-organisms, flora, and fauna, to be thoroughly investigated over very considerable periods without undue interruption.

But the investigation of the soil arthropod fauna did not get off to a very good start. Charles Darwin's treatise on earthworms, published in 1881, following his earlier work, seems, at the time, to have been considered to be so authoritative that earthworms (which are big and obvious) would appear to have become the only soil animals worthy of notice for a long time thereafter. Admittedly Sir H. Drummond, in 1887, drew attention to the role of termites in the soil, but chiefly to point out how these were supposed — wrongly in some respects as it happens—to be the tropical analogues of earthworms.

It is sometimes suggested that Antonio Berlese, early in the present century, set the scene for the intensive study of soil arthropods by his introduction of a crude flotation technique and of the extraction funnel which bears his name and which he used to obtain small soil and litter-inhabiting arthropods (principally mites); his two methods still form the ultimate basis upon which the majority of present-day extraction devices operate. Certainly Berlese has legitimate claim to fame on this and on many other scores, but it would perhaps be doing less justice to those who followed him, and to men like Karl Diem whose short paper on the soil fauna of the Alps (1903) was published before Berlese's description of his apparatus (1905), if the latter were given more than his fair share of credit. If any one person were to be singled out as "the father of modern soil zoology", this honour should probably go to C. H. Bornebusch, whose study of Danish forest soils in 1930 is a classic which has provided a basis for much of the subsequent ecological research in the field. Earlier work on soil arthropods was done in England (for example by A. E. Cameron, H. M. Morris and M. Thompson), in Scandinavia (for example by A. Tullgren) and elsewhere, but Bornebusch's contribution was undoubtedly the most important since the time of P. E. Müller.

Workers in Britain and Scandinavia (particularly Denmark) have continued to be very active in the study of soil zoology; there is also a strong tradition in Austria; Germany, the Soviet Union, France and the Low Countries also have active schools of rather more recent origin. The study of the soil fauna in the Americas has also had its adherents, but these have been relatively few, the most consistently devoted author having been the late Dr. A. P. Jacot, who worked on New England forest soils and who has given us some of our most picturesque accounts of their fauna. In the pre-Bornebusch era, J. W. McColloch and W. P. Hayes were among the first American authors to discuss (in 1922) the interrelations between insects and the soil. The main interest in North America (as would be expected) has been of a purely practical nature and related to the study of soil pests (by no means neglected elsewhere); Prof. J. H. Lilly, now at Amherst, Massachusetts, has twice reviewed the field recently. In Canada even K. M. King was principally concerned with directly practical considerations (some of those who assisted him are present here). But there are faint signs of awakening interest in the general soil fauna, both in the United States and in Canada. A stimulus to the study of soil arthropods in the former country has recently come from an indirectly applied field, the study of the general biological effects of radioactivity and of radiation hazard.

CURRENT TRENDS IN RESEARCH

It is impossible in this address to cover the whole field of soil arthropod investigations, so I shall devote the rest of my time to reviewing very briefly some of the more recent developments and trends in research methods. I do not intend to discuss the very numerous groups of arthropods found in soil and litter, since these are not the subject of my talk.

Research methods used in the study of soil arthropods may be grouped roughly into five main categories:

1. Extraction Processes: Like Mrs. Beaton's recipe for jugged hare, which I believe begins, "First catch your hare . . .", first catch your fauna!
2. Methods of Identification: Having obtained your soil arthropods, inspect them in order to ascertain what it is you have caught.
3. Techniques for Biological and Physiological Research: Having discovered what animals inhabit the soil, find out how they live and function and "what makes them tick".
4. Analysis of Results: In ecological (including economic) work it is necessary to be able to draw valid conclusions from quantitative data obtained.
5. Methods of Assessment of Interaction between Fauna and Soil (and its inclusions): What does it all add up to?

Extraction and Accessory Processes

Direct Collection. This has limited applications and is mainly used for larger forms and particular groups. It often merely consists of a limited amount of sieving and of picking out the arthropods against a white (or black) background over which the sample is spread. A recent tendency, however, is to use coloured backgrounds (green or blue) in order to detect both pale and dark forms simultaneously with comparable ease. Much of the tedium of collecting may be eliminated by the use of a Winkler-type semi-automatic collector, or similar device, but these have been in use by coleopterists on the Continent of Europe for many years and are scarcely to be regarded as new! For routine surveys of larger animals, fully-automatic soil-sifting devices may be used. These are often very elaborate, powered, mechanical devices which are costly and of limited application. For micro-arthropods direct sieving methods are too inexact and much of the fauna will be missed beneath, or within, small soil particles.

From larger litter particles it seems that micro-arthropods, particularly mites, may be collected by a modified "brushing" technique similar to that devised by C. F. Henderson and H. V. McBurnie for counting spider-mites on foliage. It has also been found that a high proportion of the soil animals on or near the surface of soil, at roots of plants and in litter may be collected by means of a "vacuum-cleaner" type of suction apparatus, like that of C. G. Johnson, T. R. E. Southwood, and H. M. Entwistle.

Heating and Drying. The use of heat seems first to have been put to practical use by A. Berlese, who, in 1905, published an account of his water-jacketed copper funnel, heated by a gas jet below, heating its lower part. The object of this apparatus was to drive the arthropods from soil and litter, held on a gauze in the upper part of the funnel, into a vial placed below. That the apparatus had the desired effect, however, is somewhat surprising, because the heat was applied from the direction in which it was desired to drive the victims. The reason that it worked is probably that drought, rather than heat is the operative factor, and the discomforted animals make for the more humid conditions, rather than the cooler ones, and thus fall downwards through the gauze.

Nowadays most so-called Berlese funnels operate on the basic principle, introduced by A. Tullgren, of having the heat source above the sample. This heat source is usually an electric light bulb (carbon filaments are best) and such funnels should be called Tullgren, rather than Berlese, funnels. Several workers such as N. Haarløv, A. Macfadyen, and P. W. Murphy have experimented with different types of Tullgren funnel, aiming at more complete extraction of arthropods and the exclusion from the collecting vessel (by means of sieve-plates and gauzes) of as many small particles of soil and other debris as possible. Different fluids in the collecting vessels have been tested for their comparative repellent effects, but it seems that the usual preservatives do not, as a rule, seriously affect the numbers of arthropods collected, except in highly critical work. Haarløv showed the importance of ventilating the funnel system so that condensation, which traps small arthropods, is reduced; he also was instrumental in illustrating the importance of desiccation, as well as heat, as a major factor in the extraction process.

In an endeavour to eliminate the condensation factor, Macfadyen has experimented with modified types of funnels having controlled draughts. Other improvements have been in the direction of making the heating more nearly even over the sample. The funnels themselves are now frequently of small size, set up in batteries, and thermostatically controlled, so that a number of samples may be given simultaneous comparable treatment — as in Murphy's so-called 'split-funnel' extractor and in some of Macfadyen's modifications. For loose litter, however, very large funnels, as big as garbage cans, are used. The slope of the sides of the funnels in most modern apparatus has become very steep in an endeavour to prevent arthropods from obtaining a foothold and thus remaining behind; the inner surfaces of the funnel must be highly polished and without seams; each funnel must be insulated from its neighbour. For small scale apparatus at least, the whole concept of the funnel has now changed; the sides have become so steep as to be vertical and the "funnel" merely consists of a hollow cylinder, open at each end and with sieve plates across it. Such funnels are also promising in the extraction of insects and mites from grain and meal.

The condition of the surrounding air has also been shown by Macfadyen to be important in both qualitative and quantitative studies, so that the location of apparatus must be carefully considered. Dry, centrally-heated rooms are far from ideal.

A handy new type of funnel for qualitative field work is collapsible and made of polyethylene sheeting; it is hung up on a tree, post, or wire, the sun

being used as the heat source. This "expedition" funnel was, I believe, invented in England, but not for home use!

So far as I am aware, all these funnel methods depend on heat from above. It might, however, be suggested that, for litter samples (where the question of disturbance is less important), what may be called a "hot rod" technique should be investigated. The fauna would be driven outwards from the centre of the sample by means of a vertical heated element inserted into the middle. The possible use of chemical repellents might also be further examined; it has proved useful for thrips (turpentine vapour) and I understand that chloropicrin has been used with some success as a general repellent. This last method is rapid, but it suffers from one serious drawback; it tends to repel the investigator almost as rapidly as it does the fauna — but this can doubtless be overcome! The use of the numerous repellents, such as dibutyl phthalate, developed for the protection of humans against trombidiid larvae should also be investigated. It has also been suggested that the medium into which the animals are driven should be made more attractive; for example, cool, moist sand (from which the arthropods could be extracted by another means later) might be proferred — such a principle is sometimes used for the extraction of enchytraeid worms (as, for example, by C. Overgaard Nielsen).

No review of extraction methods of this kind, which depend essentially upon the movements of the animals themselves, would be complete without some reference to the treatmnt of the sample. It seems that, where possible, the sample should not be broken up, but should be left intact and inverted. Those animals which are only able to penetrate to shallow depths thus have the least distance to go to make their escape through the soil. The objection to breaking up the sample is that arthropods often become incarcerated in rapidly drying fragments of soil before they have a chance to escape. P. W. Murphy has very recently given a review of the basic techniques of sampling soil and litter and of how to deal with the material once it has been obtained.

"Wet" Methods. The chief "wet" method is flotation, but the processes now employed are far removed from the early boiling-tube and plunger first used by A. Berlese at the beginning of the century. Present techniques first use wet sieving, based upon the method of H. F. Morris published in 1922, to get rid of large particles and bigger animals. After this, organic matter is floated on a salt solution in which mineral particles sink, the animal and vegetable components being subsequently separated from each other. The special flotation tank (in which was placed magnesium sulphate solution) was introduced by W. R. S. Ladell in 1936, but it was not until G. Salt (whose Canadian ties are well-known to those present) and F. S. J. Hollick, in the early days of the last war, refined Ladell's apparatus and used benzene or xylol for separating arthropods from other organic matter, that flotation became a really practicable proposition.

Flotation is complementary to, and not competitive with, other extraction processes. Wet methods have the advantage that they extract inactive stages, such as eggs and pupae, and that they are effective in clay soils with low organic-matter content where funnels are inefficient. They are not so effective in soils with a high organic-matter content (although recent work has shown them to be more efficient under these conditions than was thought), and they have the disadvantage that they extract both the quick and the dead without discrimination, usually killing the living material and often rendering it indistinguishable from the recently deceased. Reasonably satisfactory funnels can be quickly constructed by the amateur from readily available material; satisfactory flotation apparatus cannot. Flotation methods tend to be messier and more time-consuming than funnel methods, but they have the further advantage that, since the arthropods are dead or inactivated first, time is not a limiting factor; extraction may be done at leisure and prompt field operations are not necessary

as they may be with funnels. Funnels are inefficient at extracting rhizoglyphid and scutacarid mites and, even under relatively unfavourable conditions, flotation appears to be the better method for these groups. On the other hand the physical properties of some animals may make flotation extraction inappropriate. Thus pseudoscorpions and many oribatids sink in water and many salt solutions; many cecidomyiid and other dipterous larvae are wetted by water and are thus removed with the vegetable matter at the oil-water interface providing the basis of present separation techniques.

The Salt and Hollick apparatus is well known to economic entomologists and need not be described here, since it is by no means a new device and its underlying principles have already been briefly referred to. Originally designed for the extraction of wireworms from agricultural soil, it has now been put to many different purposes and as a general all-round extraction method, is difficult to improve upon. A modification for large-scale routine sampling of insects is that of G. F. Cockbill and his colleagues who sacrifice some accuracy for economy by using brine instead of magnesium sulphate and kerosene instead of benzene. More recently F. Raw has produced a refined version of the Salt and Hollick apparatus, designed to cope with the very smallest of soil arthropods. Smaller samples are used and these are broken down more efficiently by means of chemical dispersing agents ('Calgon' or 50 g. sodium hexametaphosphate and 20 g. sodium carbonate per litre) at reduced pressure; for the final extraction a finer sieve (phosphor-bronze of 360 meshes per linear inch) has been introduced. A general improvement, also introduced by Raw and applicable to the original technique, is the freezing of the benzene layer so that it can be removed as a plug to a sintered glass filter funnel in which the arthropods are retained.

In France, J. d'Aguilar and his colleagues have developed a rather different type of extraction apparatus, based upon the same general principles and using equally fine gauze; potassium bromide is used for flotation and sodium citrate in the initial dispersion of the sample. The apparatus is probably cheaper to construct and quicker to use, but it seems more prone to stoppages and is possibly less efficient.

Other methods of wet extraction which suggest themselves include the utilization of differential sinking rates in fluids of different densities and in vertical up-currents (similar to methods used for soil nematodes). The use of foaming agents and detergents may also prove to be of promise in the future although little has been done so far regarding these possibilities.

Identification and Associated Techniques

The unsatisfactory position regarding the systematics of soil and litter-inhabiting arthropods has already been referred to; it bears repeating, but I shall resist the temptation to do this at length since we are restricting ourselves largely to the consideration of research methods. Under this heading, therefore, we are concerned principally with methods of preserving and mounting soil arthropods for identification.

Satisfactory preservation of animals for study is of the greatest importance, but many of the older descriptions of soil animals are based upon material so poorly preserved and mounted that it is often difficult, if not impossible, to recognize species, even if they are compared with the type specimens. It is amazing how many new species can be erected by the simple expedient of squashing a single species of mite or collembolan on a slide in a number of different ways, particularly if they have previously been "preserved" in some strong depilatory and have subsequently been smeared over a slide in some adequately distorting medium! This is well appreciated by the few specialists at present working on soil-inhabiting animals, and active research on better methods of preservation and mounting is in progress.

For the actual examination nearly all authorities are agreed that some form of cavity slide is required. For mites G. O. Evans has described one made from transparent plastic in which the cavity is deeper at one end than the other, so that, by manipulating the coverglass to suit the size of the mite, an undistorted view may be obtained. E. von Törne and H. Gisin have developed soft-wax cell techniques which are probably the simplest for the general worker; more specialized cavity slides can be ground as required and M. Hertig's use of a dental drill for this purpose has been recalled. Various sealing preparations for permanent mounts have also been developed, some of these being based on wax-lanoline mixtures; Thorne's cement, as used by nematologists, would probably prove satisfactory also.

So far as fixatives are concerned, Oudeman's fluid or 80% alcohol are still generally agreed to be suitable for many mites, but Gisin's recently improved formula is said to be better than former media for collembola. Lactic acid is now used extensively in making up mounting media although the formulae differ for various groups. Ordinary lactophenol is used for mites. Polyvinyl alcohol is recommended as a mountant by some, such as J. T. Salmon, but its use requires considerable care and some specialists will have nothing to do with it. It appears to be quite unsuitable for mites because of its distorting properties. For general purposes permanent mounting is frequently unnecessary; specimens may be stored in tiny vials or capsules submerged in preservative.

Larger soil arthropods do not usually require methods different from other arthropods, but it might be noted that soil-inhabiting insect larvae are probably best preserved in Pampel's fluid, since this distends them somewhat and permits the mouthparts to be examined.

Biological and Physiological Investigations

One method of attempting to study the biology of an animal is to try to rear it in the laboratory. This has serious drawbacks in that artificial conditions are created, which may lead to faulty conclusions being drawn concerning what happens in nature. Nevertheless, if one is successful in rearing the animals in question, this will at least assist one in recognizing the different stages in the field.

To date the chief method of rearing soil animals has been to attempt to raise them in cells or chambers, usually of a porous nature (such as dental plaster), or in glass vessels with porous bottoms so as to maintain humidity. C. D. Michener used this method for trombidiid mites a dozen years ago, and various modifications have since been made for other animals (for example, by C. A. T. Edwards for Symphyla and by J. W. Stephenson for millipedes).

Culturing micro-arthropods has proved to be very troublesome because of the difficulty of coping with excess moisture, which may immobilize and kill the animals, and with contamination by fungi and other micro-organisms. P. W. Murphy has overcome some of these drawbacks by the use of culture cells having replacable sintered glass bottoms beneath which is a water-filled tube and syringe. The whole apparatus can be readily sterilized and cleaned and any excess moisture can easily be drawn off from below by means of the syringe; artificial flooding, also from below, is possible if required.

With regard to nutritional experiments, no artificial diets are so far known for soil micro-arthropods[1], but known strains of fungi can be kept isolated for feeding fungivorous species. Many of the techniques used for rearing mites associated with stored products are also applicable to soil-inhabiting species and this field has recently been reviewed by M. E. Solomon.

[1]For larger soil arthropods such diets have been worked out, e.g. in Canada for certain "root maggots" (larvae of anthomyiid Diptera) by W. A. Friend.

Behaviour studies on certain root-feeding maggots are possible by direct observation through alginate gels in which seedlings are germinated. This technique, which was developed in England by Miss Barbara Stokes at Rothamsted, may have considerable possibilities. Behaviour studies in the laboratory can also be made by the aid of high-speed flash photography and cinematography as described by C. C. Doncaster.

In order to discover what happens beneath the soil in nature, much reliance must still be placed upon serial soil sectioning by the well-known, elegant technique of N. Haarløv and T. Weis-Fogh. This technique uses agar-agar as an imbedding medium, but G. Minderman has recently modified the technique (especially for studying nematodes) by using gelatine for imbedding and hydrofluoric acid for eliminating troublesome mineral particles.

H. T. Tribe's method of determining the fate of cellulose by inserting coverglasses coated with cellophane vertically in the soil may be applicable to the study of the feeding habits of certain arthropods; O. Gilbert and K. L. Bocock have used nylon hairnets to contain litter samples in an undisturbed condition. Nobody yet seems to have attempted to use fine endoscopes, such as are used by the medical profession and in industry, for direct observation on the behaviour of the fauna beneath the soil, or even in ants' nests.

Radio-isotopes have been utilized in the study of behaviour of soil insects large enough to be marked, released, tracked whilst underground, and recovered. Tracers have also been utilized in an attempt to establish prey-predator relations among surface-feeding animals and there is no reason why this method should not be applied to the subterranean fauna. Recently P. L. Berthel has endeavoured to discover, by the use of radioactive tracers, what certain litter-feeding mites were eating. Prey-predator relations have also been investigated by means of precipitin tests, for example in attempting to determine the role of carabid beetles in reducing wireworm populations.

In the field of soil-arthropod physiology, probably the chief recent development is A. Macfadyen's much improved respirometer. This instrument, designed for individual small arthropods gives a fairly accurate picture of the animal's activity under conditions not too far removed from natural. It incorporates, in a single unit, the previously established ideas of a compensating chamber in the same block as the rest of the apparatus (so that temperature effects are virtually eliminated) and the automatic generation of oxygen by electrolysis as demanded by the animal under investigation. This apparatus, in its most recent form, has a most ingenious method of automatic recording.

Analysis of Results

Before the last war K. M. King emphasized the need for sound sampling methods and statistical analysis of data; and in recent years considerable attention has been paid to these aspects. To assist students, M. J. R. Healy has summarized the basic statistical techniques most useful for work with soil animals.

Since statistical work began, it has become quite obvious, as with animals in other habitats, that the soil animals are not randomly distributed; they are patchy, and this is clearly shown to be the case in root-knot nematodes (by J. D. Wilson), in earthworms (by J. E. Satchell), in enchytraeid worms (by C. Overgaard Nielsen), in Japanese-beetle larvae (by C. I. Bliss), and in mites (by P. W. Murphy). Recently, L. Nef in Belgium has found that in a number of species of soil mites there appears to be a negative binomial (Pascal) distribution, and it is suggested that this is probably true of a wide range of soil animals.

So far as the sampling pattern for the soil fauna is concerned, Nef is of the opinion that random samples are preferable to systematic ones. R. D. Hughes has made a new suggestion: he proposes that, in order to overcome difficulties caused by aggregated populations, paired samples be taken, one sample at

random and its pair at a fixed distance [and direction] from it. M. D. Mountford discusses the use of a new "index of similarity", independent of sample size, for the classification of sample sites; and J. G. Skellam has discussed from a mathematical viewpoint, the estimation of [soil] animal populations obtained by extraction processes. Skellam's conclusions may be summed up in his own words: "The assumption of homogeneity, may lead to serious underestimation. The effects of heterogeneity, whether in time or space, or within the population, are basically similar and not analysable separately. Theoretical studies reveal some formidable inherent uncertainties." There is, in fact, a long way to go when it comes to analysing our results in a manner which will enable us to be sure of our conclusions.

Interaction between Soil and Fauna

The effect of arthropods on certain types of soils (mull) was discussed long ago by Müller and, in respect of termites, by Drummond. It was not until much later, however, that the subject was studied at all intensively, or mutual interrelationships discussed. In America, J. W. McColloch and W. P. Hayes were amongst the first to do this latter, although they were mainly concerned with insects. A. P. Jacot in the 1930's observed how fungi were often necessary to prepare, or "soften", vegetable matter before arthropods could attack it. Once animals have accelerated the breakdown process, however, life is made much easier for micro-organisms, since animals comminute the organic matter and, in so doing, increase the surface area upon which the micro-organisms can work. The effects of surface vegetation on the distribution of the fauna are also receiving attention, for example, by C. J. S. Fox in Canada.

It is more or less impossible to single out research methods aimed primarily at establishing the degree of interrelationship between the soil and the fauna, since most of what can be discovered depends upon the interpretation of results obtained by methods already discussed. Nevertheless certain rather secondary investigations in other fields may be of major importance in studying these interrelationships. For example, the study of the composition of faecal pellets in the laboratory helps us to determine something about the biology of the species in question, but when the information is taken to the field, the proportion of such pellets (which are often very characteristic) in the soil will indicate the kinds of animals principally concerned with the natural breakdown of litter and the extent to which they are involved — a sort of soil "pharmacognacy".

A very recent method of estimating the rate of disappearance of litter is discussed by P. W. Murphy. A small spot of Tantalum 182 is painted on leaves before they actually fall to the ground and thus the fate of leaves of a known age in the litter can be established. By the extension of this technique it may be possible to determine, to some extent, the role of the arthropods feeding on such leaves, but the ecological picture as a whole is so complex that the ultimate goal is very far from being achieved.

Comminution of organic matter is one important function of the soil and litter fauna, but there is another, namely translocation. Earthworms have long been known in this regard, but it would appear that certain arthropods (notably millipedes) are also important in mixing organic with mineral matter in their intestines. Even small arthropods such as collembola, when examined under the microscope, may be found to contain considerable quantities of mineral matter in their guts. In addition to the study of faecal pellets, therefore, the investigation of the gut contents of soil arthropods helps to give us greater insight into their role in mixing and binding mineral and organic matter and thus in humus formation in the soil.

The possibility of using certain "indicator" species to provide information on soil conditions is always one that appeals to the ecologist. H. Gisin has found that there is some correlation between certain collembola and fertile vineyard

soils in Switzerland, but he warns that inaccurate determinations (all too easy to make) may give quite wrong impressions. M. S. Gilyarov has claimed that the soil fauna is of value to the pedologist in classifying soil types. Twenty years ago K. M. King looked forward to the day (which has not yet come) when changes in indicator species would act as a warning that something was amiss with a particular soil and that this would enable us to take appropriate measures to rectify the situation before it was too late. Mention has already been made of current investigations on soil fauna in the United States in relation to radioactivity.

While touching on practical implications, it might be appropriate to refer to the effects of cultivations and protective chemicals on the soil fauna. So far as methods are concerned, however, there is little to add to what has already been discussed. In Germany and Austria in recent years, experiments involving the use of various implements and manurial treatments in statistically arranged plots have been done with a view to discovering what happens to the fauna under differing conditions. Similar trials using different insecticides have also been undertaken in various countries.

Time precludes any discussion of the results of these experiments which are, in any case, mostly inconclusive, but it should be noted that at least some synthetic insecticides give cause for alarm if used wholesale on the land without first ascertaining the long-term effects on the fauna and ultimately on soil fertility or on potential new pests. On the other hand, it may be suggested, as it has been by M. E. Solomon, that experiements on the judicious use of soil insecticides and acaricides might indicate the possibility of improving, rather than impoverishing, the soil by regulating the fauna to suit our own ends.

CONCLUSION

In conclusion we may perhaps make a few suggestions as to the directions in which the study of the soil fauna may be expected to move.

Firstly: with regard to extraction processes, these will doubtless be refined still further, particularly in respect of improving the rate of recovery of certain "difficult" groups. Some entirely new methods of extraction to supplement, or even, in some cases, to replace the current vogue for funnel and flotation techniques may be expected for certain groups. The best way of taking samples from a given soil must also be determined beyond doubt.

Secondly: there should be a much greater amount of critical systematic work in respect of the soil fauna of most parts of the world. Special attention must be paid to immature forms, since these comprise the bulk of the fauna. Regional keys to species and general generic keys for the non-specialist must be produced. Preserving and mounting techniques for different groups must be perfected and more nearly standardized.

Thirdly: more attention must be paid to detailed life-history studies of collembola and mites in particular (since they comprise the bulk of the arthropod fauna). Food preferences and prey-predator relationships should be established by means of improved laboratory techniques coupled with improved methods of direct observation. Improved methods must also be found for studying the physiology of soil arthropods — not only in respect of respiratory activity, but also with regard to nutritional requirements and general metabolism — so that their role in soil formation can be ascertained.

Fourthly: sampling techniques and the methods of analysing data obtained in ecological work must be improved so that conclusions may be more accurately drawn from experimental data.

Fifthly: There must be general progress in methods of studying and utilizing our knowledge of the interaction between the arthropods and other fauna,

the microflora, the soil and the surface vegetation. The importance of arthropods in the breakdown and translocation of organic matter in soil must be more intensively investigated, both in respect of the quantities of material involved and, equally important, the time taken to utilize the available store of food. More accurae methods of measurement must be sought.

And finally: We may eventually expect the development of more general methods of utilizing indicator species in soil classification, fertility determination and the effects of radiation. Possible environmental control of the soil micro-organisms in the nutrition of soil arthropods and the role played by arthropods in the nutrition and dissemination of soil micro-organisms (including plant diseases).

We must aim at greater and closer co-ordination of the various soil sciences. Pedologists, soil chemists and soil microbiologists in the past have, for the most part, turned a blind eye to the teeming animal life in the soil, but gradually, through the efforts of a handful of research workers, mainly zoologists, but including far-sighted pedologists such as P. E. Müller and W. L. Kubiëna, the importance of the soil fauna in general, and of the arthropods in particular, is being increasingly recognized.

I commend this comparatively new field to you as being worthy of your attention.

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(Accepted for publication: November 21, 1958)

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II. SYMPOSIUM

TRENDS IN CANADIAN ENTOMOLOGY: TEACHING[1]

J. G. Rempel[2]

The subject assigned to me proved to be more difficult than anticipated. I had hoped to secure most of my information from courses of study outlined in University calendars. I soon learned that University registrars are most adept at hiding whatever information might prove useful to an outsider. I, therefore, communicated with heads of departments of biology, zoology, and entomology, and also with members of Science Service, Canada Department of Agriculture. It is a pleasure to acknowledge the fine cooperation of all contacted.

In dealing with the subject "Trends in Teaching", I do not intend to limit myself to mere presentations of the present situation. I also propose to outline trends that I would consider desirable. I hope that this will stimulate discussion.

PREPARATION FOR ENTOMOLOGY

Teaching of entomology is the concern of the University. It involves, first, the instructor who gives out the information, and, second, the student who receives information. Hence the excellence of instruction will depend on both, the donor and the recipient. Let me deal with the latter. The status of the recipient is greatly colored by previous training. His educational background may dictate the quality of education which the university can offer. Many of our difficulties are closely linked with the inadequate preparation of our students for university work. Thus, a large part of the first two years of college is devoted to the remedy of this situation. I have been told that an undergraduate student from a Canadian university going to the United Kingdom finds that he is two years behind the English student in educational achievement. No doubt he would face a similar situation were he to go to a Swedish, or a German university, or to a university of the Netherlands. Until our educational endeavours at the lower stages are raised to a higher level, our achievements at the university level will fall far short of our desired goal.

A weakness in the training of Canadian entomologists was clearly evident at the Xth International Congress of Entomology. Foreign, especially European, workers could converse readily in several languages. I found that some delegates were equally at home in two or even three different languages. They thus possess a tool that must assist materially in the search through entomological literature. Moreover, their life is much enriched. The average English-speaking entomologist of this country does not even speak French, our second official language. He often does not even possess an adequate reading knowledge of French. I find this quite disturbing. Furthermore, some of our educational institutions, on the college level, make no attempt to correct the situation. Thus, the Ontario Agricultural College, which trains a large number of entomologists, does not offer a foreign language during a four-year undergraduate course. I see no provision for French or German at the undergraduate level at Queen's University, at the University of New Brunswick and Macdonald College, although some of the students at the latter institution are bilingual. Most Canadian universities, however, do require a reading knowledge of French. Lately there has been a trend toward German. At Saskatchewan, German is compulsory. My information is that this is also the case at Toronto, at Western and at Alberta; but that our students will ever reach a stage where they can converse in another language

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[1]Presented as part of a symposium on trends in Canadian entomology to the 95th annual meeting of the Society and the 8th annual meeting of the Entomological Society of Canada, Guelph, Ontario, October, 1958.

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seems to be a forlorn hope. To achieve such a goal, we should offer a foreign language at the primary level of education, and adopt the methods of teaching languages used in European schools.

UNDERGRADUATE TRAINING FOR ENTOMOLOGY

I intend to devote little time to the discussion of the status of the instructor in entomology. There is general agreement that he should excell not only in his specialty, but should also achieve at least a moderate degree of excellence in general scholarship; he should be an idealist, an enthusiastic and inspiring teacher, and a keen research worker. It has been unusually difficult for universities to find men of this calibre. Moreover, there is the eternal problem of replacing those who retire. It is never easy to replace an E. M. Walker, an E. M. Du Porte, an E. H. Strickland, or a George Spencer. In addition, universities are faced with prospects of great expansion in the near future. Where can they turn for the additional recruits? In the past, salaries have been low, pension schemes poor, travel grants inadequate, sabbatic leaves a luxury. Such conditions do not attract bright young men. Fortunately, a trend toward higher salaries is unmistakeable, a trend that will help greatly to lift entomology at the university to higher levels.

Only four Canadian universities have departments of entomology, namely Alberta, Manitoba, Toronto at the Ontario Agricultural College, and McGill at Macdonald College. Other Canadian institutions offer entomology in the department of zoology, still others in the department of biology. In the universities where the department of entomology is in the College of Agriculture, it is also possible for students to specialize in entomology in the College of Arts and Science.

It is difficult to compare the curricula in the various institutions. Universities with a separate department of entomology offer several courses in the field, dealing with aspects of morphology, taxonomy, physiology, and ecology. The additional training in entomology here appears to be chiefly at the expense of botanical subjects. In universities with a department of zoology or biology, training is more along broad biological lines, and work in entomology may be restricted to one two-term course. I freely admit a bias toward the second type. It assures a broader background for the student and postpones the evils of early narrow specialization. Furthermore, the increasing importance of chemistry, biochemistry, physics, and mathematics in entomological education makes a trend toward the second type inevitable.

Let us now see what major changes in the curriculum have been made in recent times and what further changes are indicated.

Until recently, what might be called adequate training in insect morphology and taxonomy was given only in the four institutions that have a department of entomology. But even here the trend is now away from this. Thus, at the Ontario Agricultural College since 1940 there has been a gradual reduction in the time allotted to morphology. The same fate has befallen systematics. In the latter field there is also evident a change in emphasis. Thus the early courses called for extensive keying of adult insects to family and occasionally to generic level, but principles and procedures in taxonomy were neglected. An awareness of the importance of the latter is now evident.

Although several institutions offer courses in economic entomology, in toxicology or in insect control, applied entomology has never occupied an important place in the undergraduate curriculum of our schools. Moreover, in one institution (O.A.C.) where applied entomology has been given for more than twenty years, the time devoted to this subject is now approximately one half that of five years ago. This reduction in time is possible with "more and more

emphasis on principles rather than details of control." At another agricultural college (Manitoba), students of entomology are encouraged to do basic research, rather than applied. In spite of the fact that insects play such a great role in our agricultural and forest economy, this reflects a healthy situation.

In common with what has happened in other biological fields, the approach to teaching in entomology has become more dynamic in recent years. This trend is clearly seen in the greater emphasis now placed on physiology. At my own institution a student in entomology is now required to take a course in each of the following: plant physiology, cell physiology, and general animal physiology. A course in insect physiology is taken in the graduate school.

In spite of the tendency to add new courses to the curriculum, it is obvious that there are still some important gaps in our training program. In the past, little time has been devoted to the study of immature forms. Since these are of great importance to fisheries and wildlife in Canada, this should be corrected. Two institutions have lately introduced a course on aquatic insects, with emphasis on immature stages.

Owing to the fact that our summer season in Canada is very short and school terms are mainly in the winter season, our students suffer a noticeable lack of training in field work, and insect ecology generally has been a neglected subject in the curriculum. Instructors are aware of this, but see no easy solution.

From the above it is apparent that the course work for the undergraduate entomologist has become seriously overloaded. Every department is searching for a way out of the dilemma by eliminating one subject to make room for another, by shifting the emphasis from one to another, by splitting major courses into series of short courses, or by transferring course work into the graduate school.

GRADUATE TRAINING FOR ENTOMOLOGY

Although graduate work in entomology at the Master's level has long been offered at Canadian institutions, doctoral work until recent times was restricted mainly to the universities of Toronto, McGill, and Macdonald College, considering the latter as a separate unit. Since Canada has a large number of entomologists, it should be of interest to know where they received their training. In search for an answer, I examined the 1957 Directory of Personnel, Canada Department of Agriculture, and the 1957 university calendars. I found in the lists 359 professionally-trained entomologists with a Bachelor's degree. Nearly all had received their first degree in Canada. One hundred and twenty-four listed one of the four western universities (B.C., Alta., Sask., Man.) as their alma mater; 108 had their degree from Ontario (Western, McMaster, Queen's, O.A.C., Toronto); 66 had graduated in Quebec (Laval, Montreal, Macdonald, McGill); 39 came from the Maritimes (U.N.B., Dalh.); eight from the United Kingdom; and 14 from the United States. It is thus apparent that we recruit our entomologists mainly at home. However, when we come to the Master's level, the picture changes drastically. In the above lists 276 entomologists had a Master's degree and nearly one-third had gone to the United States for the degree. A further glance at the Directory revealed that of 238 federal entomologists with Bachelor's and Master's degrees, 101 had taken the master's at their alma mater, 137 at a different institution. If we had included those who proceeded to the Ph.D. directly after the Bachelor's, there would have been an even greater increase in the number that changed universities. In other words, Canadian students like a change of scenery. It is generally agreed that students should become familiar with more than one institution and that the change might well occur at the M.A. level. From the above, it would appear that the situation in Canada is a healthy one.

At the doctoral level the trend to go abroad, especially to the United States, is even more pronounced. Fifty per cent of our Ph.D.s of the 1957 list graduated from an American institution. We might well ask why do Canada's students go south for postgraduate work in such large numbers? Is it because American schools are large? Is it because they offer course work not available at home? Is it because of a difference in standards, either harder or easier? Are American schools staffed with greater men? Are they schools which offer more financial help and better facilities for research? Or is it simply a case of "distant fields look green"? Whatever the answer, we cannot be proud of the situation. A nation that aspires to lead an important and prominent role in world affairs should have satisfactory facilities at the highest levels for the education of its leaders. Surely in Canada we should have not only one, but several, graduate schools in which training in entomology is equal to the best available in American or European schools.

OUTLOOK FOR THE FUTURE

I have outlined briefly past trends in the education of Canadian entomologists. Are these trends along sufficiently clear and definite lines to enable us to project them into the future? Are these trends deeply seated and rigid, or are they elastic and easily bent, if we so desire?

The members of my audience will agree that a profession must at all times have before it a goal, an ideal, and that every effort must be made to achieve that goal. I assume that we agree what that ideal is, and it is my function merely to suggest an approach for its attainment.

We must continue to work toward a higher standard of education in the primary and secondary schools, for this not only forms the necessary basis for subsequent education, but it determines the future character of our society. What is most urgently needed to bring about improvement is a realization on the part of the educators, the students and the general public that *all learning is hard and painful work.* Teachers Colleges on this continent please note! In my opinion the curse of progressive education is to be found in the theory that education is all fun. This leads students to fritter their time away in endless entertainment. Every year freshmen at the University tell me that they did little work throughout their high school years. The bright university freshmen realize that they have been cheated, and while some are bitter about it and are anxious to make up for lost time, others merely want to continue the established pattern. The latter eventually fall by the wayside. But the wastage of potentially good material is frightening, especially at a time when the mobilization of biologically superior human resources is essential to our survival. That an improvement can be brought about speedily, I doubt. We are still faced with this vicious educational philosophy, with a thoroughly spoiled youth and a pleasure-seeking public, with the colored comics, the movies, the automobile, with those time-robbing modern gadgets as the telephone, the radio, the T.V. set, and, finally, with a disturbing over-emphasis of athletics. Within recent years a number of outstanding dissertations critical of our elementary school system have appeared in press, notably Dr. Hilda Neatby's book entitled *So Little for the Mind.* Their impact on the public has been promising, but their effect on the professional educators and the teaching profession generally has been disappointing. However, the universities are not entirely helpless. We have a trump card and the time has come when we must play it. In Canada, a senior matriculation certificate opens the door of the university to the student. This we might abolish and, instead, introduce nation-wide entrance exams. Not only would this have a salutary effect upon the educators, but it would enable us to select our students. In adopting this procedure we would be merely following a precedent set by

European universities long ago. The extra effort on our part would be quickly repaid by the better average type of student on our campuses.

In Britain, for example, the total student body in the universities is numerically approximately the same as in Canada, but the total population is more than three times as great as ours. Hence, the competition for university places is fierce, and only students of unusually outstanding ability and good study habits are accepted. The work in British high schools is of such high calibre, that universities have recently dropped the first year and have thus reduced the university course from four to three years.

Although curricula and standards in our universities vary, I feel that on the whole our performance at the undergraduate level is reasonably good. There might be greater emphasis on principles and less on detail. We might reduce the work in entomology to one introductory course and draw more heavily on the other phases of biology, on chemistry, on physics, and on mathematics. I should like to see us introduce more subjects from the humanities, especially foreign languages. We might give fewer lectures and assign more reading, more essay work, have more discussions and more seminars. The function of the undergraduate course, after all, is to give the student a broad but solid background and a firm foundation for future work.

I should like to see Canadian universities establish a three-months summer course in field biology and make attendance compulsory for all entomology students upon completion of the third year. The course should be well integrated and should involve plant taxonomy and ecology, general invertebrate zoology, insect taxonomy and ecology, general vertebrate zoology. The emphasis would be on field work and independent student efforts would be encouraged. The course could be given every year, but in rotation by the different universities. Thus, the west coast province and the three prairie provinces might co-operate.

If the objection be raised that students use the summer vacation to increase their financial assets, it should be pointed out that in Britain students are expected to use the summer months for study and paid vacation work is frowned upon. It is true, of course, that in the United Kingdom, state support is granted to 90 per cent of the students, while in Canada the student generally must earn his support. It is possible that the National Research Council would establish scholarships of an amount adequate to compensate good students for the loss of earning power.

The first year of postgraduate work might serve for specialization and introduction to research. This could be achieved if the problem assigned for the Master's degree were not so long and so difficult as is commonly the case. I have seen Master's theses that come rather close to the doctoral thesis. In any case, if we insist on a fair amount of course work at this level, we must reduce research. A student who has had only one formal course in entomology should now concentrate on taxonomy, physiology, and ecology.

After the second degree, the student should be permitted to devote all his time to research. The most common criticism of American Graduate Schools is that the candidate is burdened with a heavy load of classes. It would appear that American instructors are in mortal fear of gaps in student training. In this respect they differ much from their British counterparts. In the United Kingdom there is no course work beyond the first degree.

For Canadian schools I propose a middle course. I advocate that, in general, lecturing stop after the Master's degree! However, as has been suggested by our chairman, a comprehensive course on scientific writing might be introduced at this stage. For most students the first preparation of a scientific publication is a painful experience. That, no doubt, is one reason why so many Master's theses never get beyond the manuscript stage. But research does not end until it has

been suitably recorded in a publication. I agree, with the chairman, that excellence of publication is just as important as excellence of research.

I feel that provision should be made to enable Canadians to obtain a first-rate doctorate degree in Canada. To this end, I should like to see established on the campus of one of our universities an Institute of Entomology, staffed by a dozen unusually gifted research workers. I advocate the establishment of such an institution for several reasons. First, as I have already pointed out, Canada is a nation that plays an important role in the councils of the community of nations, and provision for training for leadership must, therefore, be found within its borders. Second, for a half a century, our graduate students have crossed the border to seek further training in the United States. Great American schools, California, Wisconsin, Illinois, Cornell, Harvard, to mention but a few, have accepted our students on equal terms with their own. We owe them a great debt, a debt we should repay, at least in small measure. Third, we need a fine institution to serve bright students from distant lands, lands that are less fortunate in material wealth than Canada.

To select gifted students, the entrance requirements to the institute should be very high, at least an honors B.A. and an M.A. from a recognized university. Acceptance should be strictly on a competitive basis and accompanied by a substantial fellowship. Although financial support might come from the National Research Council or the Federal Government, control should be vested in the Board of Governors of the degree-granting institution.

Selecting the locale of the institution would pose a serious problem. However, if funds were available, several Canadian universities might be interested in the establishment of such an institute.

(Accepted for publication: January 15, 1959)

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TRENDS IN ENTOMOLOGICAL RESEARCH IN CANADA[1]

B. N. Smallman

In an address to the jubilee meeting of the Association of Applied Biologists, Sir William Slater stated, "Research has been defined as the systematic search for knowledge, but this definition is incomplete unless we place limits on the knowledge we seek". He went on to say, "We may seek knowledge for two justifiable reasons; the one in order to understand fully the natural processes which surround us and to establish the laws which govern them, the other in order to solve some immediate practical problem".

This dualism has presented a dilemma for entomological research in Canada. In the past it was customary, at least in theory, to resolve it by assigning the elucidation of natural processes and their laws to the universities, and the solution of practical problems to agencies serving the public directly. According to this partitioning it was appropriate in the early 1900's for E. M. Walker at the University of Toronto to work out the systematic position and morphology of *Grylloblatta campodeiformis,* while Norman Criddle, in the Dominion Entomological Branch, developed poison baits for grasshoppers. But a central and

[1]Contribution No. 3902, Entomology Division, Department of Agriculture, Ottawa, Canada; presented as part of a symposium on trends in Canadian entomology to the 95th annual meeting of the Society and the 8th annual meeting of the Entomological Society of Canada, Guelph, Ontario, October, 1958.

striking feature of the recent development of entomological research in Canada has been its overwhelming concentration in government. Over 90 per cent of the professional entomologists in Canada are employed by the federal and provincial governments. Under this sponsorship, entomology has developed largely as an applied science and has been justified on the basis of Sir William's second objective for research—the solution of practical problems.

This must remain our overriding objective. In a community so largely directed towards this goal it is natural, though regrettable, that the old partition has largely disappeared and the universities are also directing their researches towards problems with practical implications. But, especially since 1945, there have been important changes in our concept of what constitutes an adequate basis for the solution of practical problems. The nature and scope of our current researches clearly show that we have recognized the essential relation between our practical objective and an understanding of natural processes and the laws that govern them. In fact, I believe that the major trends in Canadian entomological research are currently based on a proposition that can be expressed as a paraphrase of Sir William's statement: that we must seek to understand natural processes and the laws that govern them, *in order* to solve practical problems.

In keeping with this proposition, emphasis is now placed on the systematic accumulation of data for construction of life tables on insects of economic importance; on use of such data in intensive, long-term studies in population dynamics aimed at an understanding of the laws that govern fluctuations in abundance of injurious insects; on study of the normal physiological and biochemical processes of insects and the effects of insecticides on them, as a means for approaching the problem of resistance to insecticides and improving insecticides; on study of insect nutrition to provide an understanding of the role of nutritional factors in host specificity or resistance, with the ultimate aim of altering the nutrient composition of the host to render it less susceptible; and on the attempt to establish the physical basis of repellency and attractiveness of materials to insects with the aim of elucidating principles for developing better attractants and repellents. These examples illustrate the trend to seek the solution of practical entomological problems through an understanding of their fundamental characteristics.

There is much evidence, of course, that practical problems are not usually solved by this means. More often they yield to ad hoc, empirical experimentation. This method has been characteristic of much of our entomological work in Canada and it has produced many useful solutions to urgent problems. One has only to think of the number of effective control measures developed by empirical testing of insecticides to realize the power of this method, which permits us to leap the gap of our ignorance on the fundamental bases of our problems and to reach satisfactory solutions. In view of our practical objectives it is not surprising to find that about 40 per cent of the formal projects in the Entomology Division are now devoted to finding or improving chemical control methods for specific insect pests. The empirical approach has been fostered, too, by the close identity of interest that has developed between many of our entomologists and the husbandries they serve. To this we owe J. Marshall's development of the concentrate sprayer; and A. D. Pickett's concern for the economic welfare of the Nova Scotia apple industry certainly played a part in his development of modified spray schedules to permit exploitation of natural control agents. Working so closely with the farmer and the forester we cannot fail to share his anxiety over the insect problems that threaten him, and to seek their solution by the method of direct, ad hoc experimentation, which has so often proved the quickest way of getting results. Systematic research to reveal the principles governing the abundance of an insect pest and the complex relation between it and its host is a slow way of accumulating knowledge, and an act of faith when undertaken

in the expectation that it will lead directly and rationally to the solution of practical problems. For many years Canadian entomologists have studied the life-histories, ecology, natural control agents, food preferenda, and behaviour of grasshoppers and the spruce budworm. Yet the present control measures against these insects are based on application of insecticides and owe little, directly, to the fundamental biological research.

When direct experiment leads to practical solution the immediacy between them tends to obscure the fact that both rest on a foundation of systematized knowledge and principles. Seldom can the applied entomologist trace the solution of his problem to some particular principle, and seldom does it derive from a single principle or even a single discipline. Rather, he draws on the whole range of scientific knowledge about his problem. DDT had to wait 50 years to be rediscovered in a climate of thought that had recognized and defined the entomological problems to which it offered a solution. Professor V. B. Wigglesworth has recently stressed that the principal role of fundamental, in relation to applied, research is to provide rational explanations for empirical discoveries and thus to build them into the permanent structure of knowledge. This solid platform then provides fresh starting-points for launching further empirical probes. It is this interplay between the search for principles and the solution of practical problems that characterizes the trend I see as central in the current development of entomological research in Canada.

From this trend, others are derived. To search for basic principles in entomology we must enlist many disciplines. The trend is unique neither in Canada nor in entomology, but is common to all the life sciences. And in common with them we have taken up the specialties of physiology, pathology, genetics, biochemistry, ecology, and toxicology and made them our own with the prefix "insect". The extent of this trend is indicated by the increasing number of papers by Canadian entomologists appearing in non-entomological journals. In the years 1946 and 1947, entomologists in the federal service placed only about 5 per cent of their publications in journals devoted to disciplines other than entomology; ten years later in 1956 and 1957, 30 per cent of the publications from this group were accepted for journals devoted to other disciplines in the life sciences. By this means we are repaying our debt to the more general sciences and stimulating their development in directions that will be helpful to us. One must weigh carefully the value of integrating entomological findings in the more general biological journals against the convenience of journals established to serve only the entomological aspects of a general discipline.

Since no one man can master the many disciplines required in entomological research, teamwork has become increasingly important. The early Canadian entomologist was a sturdy individualist who generally undertook and brought his work to completion single-handed. I am glad to say that in my present position I often encounter the heritage of this individualism! But it has been modified sufficiently to allow increasing collaboration between entomologists and their fellow scientists in allied fields. About one-third of the recent publications by entomologists in the federal service have appeared under joint authorship. The establishment of federal composite laboratories has fostered this trend, as indeed it was intended to do, as well as to provide exensive equipment for joint use. In terms of equipment, however, we have learned that two brains cannot live more cheaply than one! The rewards and, increasingly, the necessity for teamwork in science are real. But there are dangers, too. As I have pointed out, new ideas and fresh starting-points often stem from random experiments; how many potential discoveries may have been thwarted by insistence on narrowly rational procedures by other members of a team. One should beware, too,

of the stagnation of permanent partnerships and, in the present mode for teamwork, of unrewarding liaisons

A third and most important trend arising from our search for the principles underlying entomological problems is the increasing depth of our enquiry. The early entomologist saw his subject broadly in its setting, but without penetrating far. Today we seek explanations at all levels from the molecular to the intimate behaviour of the individual insect and to the complex interactions between the insect, and its host, its parasites, its diseases, and physical environment. The price of the deeper insight afforded must often be the failure to see our subject as a whole. In entomology as in all other sciences, the need for significant synthesis is becoming increasingly difficult and increasingly urgent.

These trends are apparent in all major phases of Canadian entomological research and they are shaping our future course. In systematics, the changing emphasis is most readily apparent in the shift from series of descriptions of new species in our own country to group revisions of genera, families, or even orders on broad zoogeographical or even a world basis. In their search for a more comprehensive understanding of our insect fauna, Canadian entomologists have flung their nets from the high Arctic to the New Guinea jungles. The influence of the "New Systematics" and the clearer concepts of the nature of species have forged closer links with the other biological disciplines. Species definitions now take account of habits, life-history and behaviour as well as morphological characters. Canadian entomologists have been quick to recognize the need to know each species as a living animal in the field, to learn its habits as a clue to its identity. The work of W. J. Brown, T. N. Freeman, and J. A. Downes exemplify this trend, and provides striking evidence of the value of this approach to the separation of species hitherto unrecognized. In pursuit of our practical objectives, immature stages, so often the "economic" stages of insect pests, are receiving increased attention. Disciplines and techniques previously foreign to systematics are being employed to unravel some of the more difficult problems. S. G. Smith has made important contributions to the taxonomy of Coleoptera through studies of chromosome numbers and morphology; K. H. Rothfels has demonstrated hitherto undetected differences between species of black flies from comparisons of the giant salivary chromosomes of the larvae; J. G. Robertson has used chromotographic techniques in separating species; A. E. R. Downe and A. S. West have used serological techniques to determine the host of biting flies —a reflection of habits, and therefore of systematics; and R. S. Bigelow and C. Reimer have applied statistical methods involving a discriminant function to separate sibling species of grasshoppers. These are the frontiers, behind which the use of conventional methods and the description of native species characterizes the main effort. There are still important gaps requiring the attention of systematic specialists, as in the phytophagous and predacious mites: but it is a happy sign that, where these exist, entomologists concerned with other aspects have learned what they need to know and have made important contributions to systematics.

Ecology is the unifying discipline in applied entomology. The principles that govern the abundance and behaviour of insects in the field and the forest are the ultimate concern of the applied entomologist, and it is here also that he must test and find the solutions to practical problems. The earliest ecological work consisted mainly of ad hoc attempts to check insect pests by altering the environment through crop rotations, sanitary measures, and modifications of tillage or cropping practices. But beginning some 10 years ago there emerged a trend of the highest significance for Canadian entomology. This trend is to undertake intensive, long-term studies embracing all measurable factors affecting the abundance of an insect in order to reach a basic understanding of its population dynamics. R. F. Morris and his associates have spearheaded this

development, basing their analyses on detailed sampling methods with known limits of statistical significance, and accumulating complete life tables over successive generations of the spruce budworm. Their work has emphasized the need to gather such information for complete cycles of insect abundance, for the effectiveness of control agents operating at low densities may be entirely different from that at high densities. The difficulties of obtaining statistically adequate data at low population densities are great; but we must be prepared to pay the higher cost of this information, for it is as important to understand what keeps the patient well as what makes him sick. Inspired by Morris's leadership, long-term studies on the population dynamics of insects in apple orchards and on annual truck crops have been initiated. One can confidently expect that these studies, directed as they are towards a real insight into the mechanics of regulation, will make important contributions to population theory.

The search for solutions to practical entomological problems through use of biological control agents shows the same trend towards a more fundamental understanding of their operation. In the past, many attempts to use biotic agents consisted in importing and releasing as many natural enemies of the pest in as great quantities as possible in the hope that some would become established and be effective. Now it is realized that the chances for success may be improved by detailed studies of the biology of the pest and its natural enemies, both in Canada and abroad, before control by biotic agents is attempted. Studies of the relations between the densities of host and parasite and of the influence of the food of the host on the choice of the parasite are contributing to an understanding of the principles of parasitism. A triumph of empiricism in Canadian entomology was the accidental introduction, with imported parasites, of a virus disease that brought about the collapse of an outbreak of the European spruce sawfly and has continued along with two parasites to keep the pest under control for the past 20 years. With this encouraging example, comprehensive studies are in progress on the efficacy of viruses, bacteria, and fungi for the control of insect pests. Here again, the trend is towards fundamental studies on the morphology, physiology, and host specificity of these organisms, and on studies to understand and improve their efficacy under practical conditions.

Insect physiology developed late in the history of Canadian entomology but is now strongly integrated into all important phases of our work. The main focal points have been problems of insect nutrition and the physiological bases for the modes of action of insecticides. A veritable school of insect nutritionists has developed and achieved wide recognition especially for pioneer work in determining the nutritional requirements for growth, development, and reproduction. On the whole, no striking differences in the nutritional requirements for different insects have been uncovered, and I would expect this type of work to turn now towards biochemical explanations of the capabilities for synthesis, or lack of them, that have been revealed. The trend towards biochemical investigations is well established at several centres, notably in metabolic studies associated with problems in insect pathology and toxicology. Serological studies have developed strongly under the leadership of A. S. West and have proved uniquely useful in identifying the hosts of biting flies — an important advance in our growing concern to know more about the role of insects as vectors of diseases both in animals and in plants. R. W. Salt's continuing studies on cold-hardiness and freezing in insects has matured to the point where he is able to link his work to the general phenomenon of nucleation. A field largely untouched in Canada and elswhere has been defined by H. Martin as chemical ecology, and concerns naturally-occurring substances that regulate the behaviour of insects. A start has been made in the identification of substances governing gustation in certain phytophagous insects, but as Martin has pointed out, a rich mine of fascinating research with a high potentiality for practical usefulness remains to be exploited.

Although chemical control of insects is the subject of another section of this symposium, I cannot fail to comment on the enormous influence it has had on Canadian entomological research. Valued chiefly as our most lucrative source of solutions to practical entomological problems, it has nevertheless stimulated important developments in fundamental work. I have already indicated that physiological and biochemical studies on normal insects have been fostered by our need to understand where and how insecticides exert their lethal effects. Pickett and his associates have learned that certain insecticides and certain dosages can be used to eliminate and examine the effects of certain predators on host populations, and Morris and his associates have obtained information on the flight range and dispersal of insects during re-invasion of DDT-sprayed forest areas. Doubts about the long-term consequences of the use of insecticides have resulted in Pickett's demonstration of the possibilities of combining chemical and natural control, and significant advances in our knowledge of the ecology of the orchard fauna. Aerial spraying against the spruce budworm in a control operation of unprecedented size has now shown that DDT has not perpetuated the outbreak by maintaining the food supply. Budworm populations are declining and it now appears that spray operations will be suspended next year. It thus appears that food is not the limiting factor in this outbreak, nor has DDT impinged on the factors causing its collapse. Certain important parasites of the budworm have persisted unaffected during the spray program; similarly, the parasite *Macrocentrus ancilivorus* has continued to exert a high degree of parasitism against the oriental fruit moth in orchards sprayed with DDT for many years. We do not yet understand the mechanisms here.

Establishment of residue tolerances has imposed new requirements and new opportunities for research. At the empirical level we must obtain data on residues at harvest to ensure that our recommendations do not result in illegal residues; entomologists will be involved in developing bio-assay techniques in the interests of their own biological studies and to meet the needs of their chemist colleagues. Above all, however, we need to understand the principles governing the persistence and degradation of insecticides on various crops so that we can predict and modify, through formulation and application methods, the insecticidal deposit throughout the period of protection. Clearly, the combined resources of the chemist, the physicist, and the entomologist are required to meet this objective.

Strains resistant to insecticides have developed in four important agricultural pests and are suspected in several others. To meet this problem we need to know the inherent variability of populations of pest insects in their susceptibility to insecticides, and to determine the rates of development and reversion of resistant strains. With such a background of information and periodic surveys of the levels of susceptibility, we may be able to anticipate the development of resistant strains by use of alternative insecticides.

I should now like to return briefly to my opening proposition and to assure you that I am by no means pessimistic about our ultimate ability to proceed rationally from principles to practical solutions. The interplay between scientific knowledge and empirical discovery will, of course, continue to provide practical solutions, but with the accumulation of fundamental knowledge about insects I believe the rational method will increasingly yield useful results. For many years it has been predicted that from a knowledge of the relations between chemical structure and toxicity it would be possible to make insecticides of high specificity. R. D. O'Brien has recently provided a convincing demonstration of the rational approach to the problem of producing insecticides with high-insect and low-mammalian toxicity. Starting from studies on the enzymic potentiation and detoxification of malathion in the roach and the mouse, he predicted that introduction of a carboxyester group into a potentially toxic organophosphate

would confer selective toxicity on the insect as compared with the mouse. A series of new compounds with this structure in fact showed the predicted selective toxicity. In the broader field of applied entomology, the science of biomathematics provides a powerful tool for the rational approach. K. E. F. Watt has recently brought this approach to bear on some major entomological problems in Canada. A mathematical model expressing the abundance of a pest this year as a function of its numbers last year, and of the relevant events that befell it in the interval, is useful for prediction. But, more importantly, it is useful in pest control. For if the model is based on parameters that have real ecological, physiological, and toxicological meaning it can tell us the factors, whether parasite, chemical, disease, or cultural practice, that regulate the population. By manipulating the model we can predict which combination of factors will minimize the increase of the pest.

One important gap remains. Despite the latitude allowed and exercised under the basic trend I have stressed, I am uneasy that in a scientific community so completely committed to ultimately practical objectives, there is no clear place and support for the man with an "off-beat" idea that has no presently discernible usefulness. I should like to support Dr. Rempel's proposal for an academic postgraduate research institute supported, I would hope, by funds without any strings, where completely unrestricted research would be done. In an otherwise robust and flowering plant we lack this vital growing point.

(*Accepted for publication: February 25, 1959*)

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TRENDS IN EXTENSION ENTOMOLOGY IN CANADA[1]

C. L. Neilson[2]

It is very difficult to find out just what the trends are in Canadian extension entomology. As a matter of fact, it is very difficult to find out just what extension entomology exists in Canada. The only things not difficult to determine are: (1) extension entomology does exist throughout Canada in every stage of metamorphosis; (2) most entomologists in Canada dabble in extension to some degree; (3) extension entomology has not developed adequately in much of Canada.

You gentlemen are in no small way to blame for the present lethargic state of extension entomology in much of Canada. Research entomology has expanded greatly during the past fifteen years. No comparable expansion has occurred in extension entomology. I am surprised that a group, such as this body of highly trained professional research and extension entomologists, has sold itself so short. Extension generally has been recognized as a provincial responsibility. Administrators of provincial agricultural services are usually trained agriculturists, but few have entomological training. Some have readily recognized the value of entomological services; others have not. We, and many of our predecessors, have failed to convince provincial administrations of their need of adequate extension entomology services. Through the medium of adequate extension

[1]Presented as part of a symposium on trends in Canadian entomology to the 95th annual meeting of the Society and the 8th annual meeting of the Entomological Society of Canada, Guelph, Ontario, October, 1958.

[2]Entomology Branch, British Columbia Department of Agriculture, Vernon, British Columbia.

entomology, research entomology could be of far greater value to the public at large and thus the stature of the science of entomology would be greatly enhanced in the eyes of the taxpayer.

In my part of this symposium, I plan to discuss what extension envolves, the role of the extension entomologist, the relationship between industry and extension, present extension facilities in Canada, and finally, suggest methods whereby research can avoid extension. It is not enough that we merely analyze the trends in Canadian extension entomology. I believe that after such analysis we should be prepared to influence these trends in a direction which will prove beneficial to all of Canada.

DEFINITION OF EXTENSION

Extension is simply communication between people. Organized and effective extension work embraces many things which could be said to consist of several processes.

A. It adapts and extends the findings of research.

B. It is a teaching process.

C. It is a co-operative process which involves research workers, extension workers, and people.

D. It evaluates extension to make sure its programs are useful, timely, and progressive.

As research men, many of you become involved, by choice or otherwise, in some phase of extension work. The degree to which such involvement in extension is necessary or desirable is debatable. Good research requires many things. Effective extension also has certain requirements. I do not agree that every research man can do effective extension work. Primarily, and at all times, it must be remembered that through extension we are trying to bring about changes: changes which normally result in a change of some sort in the way of life of those who adopt our recommendations. To be an extension worker, and not merely a dabbler in extension, one of necessity becomes involved in sociology on many occasions. It is often necessary to appreciate something of the background of a community, commodity group or groups, or individual with whom we wish to effect a change. In other words, we must analyze and limit the problem by discussion with interested individuals or groups within the problem area. Having done this, and agreed that the problem exists and *needs rectifying* for the betterment of the group or individual, there now begins a process of diffusion of information to the ultimate user or benefactor of the program.

I believe it is at this early diffusion stage of an extension program that the untrained extension worker fails to appreciate extension fully. This diffusion process goes through a variety of stages. It starts from awareness of new information, to interest, to evaluation, to trial, and finally to adoption of a recommendation or practice. It is seldom a rapid series of changes, except in a few individuals. It is a process that takes time, organization, money, and the ability to instill in people the desire to do for themselves. It is a process that involves a knowledge of the sources from which different groups acquire new information. It is a process that involves knowing what percentage of this new information is derived from a particular source during the various stages of the diffusion process. Any program that is to fully succeed must be so designed that it is "their" program, not ours. This takes careful planning, organization, and execution to get people involved in doing things for themselves. We try to supply incentive and initiative. We bring know how, materials, and equipment together, and where necessary, help with financial arrangement.

As a research worker, you have (as I have done in the past) talked to a group on some new control measure or problem, after a direct request from

growers, horticulturists or agriculturist representatives, or even after organizing your own meeting. Perhaps you have left such a meeting feeling that there was nothing left to say or do on the subject. You had given them the last word and then the onus was on the grower. If so, how wrong you were! Actually, in most cases, the diffusion process of information was just beginning and the extension problem solution was barely getting under way. It depends at what stage in the information diffusion process you entered the picture.

ROLE OF THE EXTENSION ENTOMOLOGIST

The role of the extension entomologist simply stated is that he be a communications expert in one or more phases of entomology. There is a gradual change in attitude among research entomologists and others regarding extension entomology. They are slowly realizing that top-notch men are required in extension, and that a good extension entomologist is rare and worth as much as a good research entomologist. The extension entomologist is at all times working on one or more of the various extension processes.

Adapting and Extending the Findings of Research

There appears, from my observations, to be a trend in research entomology to increase the amount of basic work being done. This is all to the good, providing it can be accomplished at no expense to the developmental aspects of applied research. If not, it will certainly place on extension an ever increasing burden. Extension must at all times be able to interpret your research. We must know what research you are doing. We would like to know why you are doing it, and what you hope to achieve. We must be kept informed periodically as to the progress of your research. Once we have this information, we can adapt and interpret it, for the benefit of growers. We must have constant access to your door so that we can provide the means of flow of new information to the grower, and also to bring grower problems to you for your consideration and action. Make no mistake gentlemen, well informed growers who know what and why things are being done on their problems are not only progressive growers, but they are your staunchest supporters.

The Teaching Process

Extension entomology is a teaching process whereby people are learning about insects. If they are learning, they are acquiring new knowledge; they are changing their attitudes and they are changing their responses towards accepting new ideas. By the acquisition of such learning, and putting into practice new and different recommendations, great changes are often brought about. We sometimes think of such changes as only an increased yield, increased production and increased net return. Actually the change may go far beyond this, for that increased yield may involve new methods or crops, new or different machinery, new working hours and conditions. In the final analysis it may influence the way of life for that individual producer and his family or for the whole community. The trend in extension entomology today is to play a more active part in this teaching process.

The Co-operative Process

Extension entomology is and must of necessity be a co-operative process. To be effective the extension entomologist must involve others in carrying a large part of the load to the individual producer. He must work with research. He should act as a co-ordinator for all groups interested in or making control recommendations. He must continually work with and through other extension agencies such as agriculture, horticulture, industry, health services, commodity and community groups. Such groups should get his special attention, for the better they are instructed and informed, the greater the dissemination of entom-

ological information to the ultimate user. No one extension entomologist or group of three or four, can personally contact every user of entomological information. He must act as a specialist and provide the technical knowledge and leadership for such groups. At the same time he must, by the nature of his training, be able to make surveys of entomological problems, undertake short term investigations and demonstrations, and prod extension organizations into action on problems that could be remedied through proper regional or district action.

The Evaluating Process

Every program should have a time of stocktaking or evaluating. Extension entomology is constantly making such an evaluation of its various programs in an effort to revise and improve its effectiveness. Those of us who are engaged in full time extension entomology are the first to admit that there is an ever increasing demand for our services. More and more people are becoming aware that entomologists exist, that they are not a "bunch of queers", and that they can perform a useful and necessary service to humanity. We are fully convinced that research entomology has far outstripped available extension services and that some changes are necessary if the public is to be kept abreast of modern advances in entomological knowledge.

CHEMICAL COMPANIES AND EXTENSION

It has been my observation that chemical companies are taking a more active part in extension than ever before. This interest is, of course, with the view in mind of increasing sales and consequently the company's profit. This is not new; any company must show a profit if it is to keep operating. The significant point is the methods by which they are entering into this combined extension and sales program.

Technical Staff

I believe it is a great credit to the chemical companies, that in the majority of cases, they are now hiring men with a technical training to back up their sales program. Besides their laboratory staffs, they are now putting at the service of Canadian agriculture and industry, field men, who for the most part, have the technical background and professional integrity to make proper recommendations, even at the risk of losing an immediate sale. Such men are rapidly developing grower confidence in their advice and products, and are doing much to dispel the attitude of growers towards salesmen of "just another sales talk". However, some of these technical men are often forced to cover a wide field, ranging from insecticides, fungicides to explosives and plastics. It is difficult to be an expert in such widely diverse fields. Such men would be well advised to seek specialist help frequently and not jeopardize the good name being built by their fellow chemical workers.

Industry-Government Relationship

There is an ever increasing awareness that chemical companies and government extension agencies are both interested in the same thing; the welfare of the consumer. Insecticide wise, this can only come about by teaching the growers the proper use of chemicals and the benefits that can be derived from such use. Grower recommendations (in charts, bulletins, etc.) are drawn up in some provinces at a joint meeting of government workers and industry representatives. In other provinces such recommendations are drawn up by government workers and presented to industry representatives prior to publication. These recommendations represent the most informed, unbiased opinions for the areas concernd. As such they are usually the guiding force behind all recommendations to growers. However, on a few occasions, a company has introduced a non-

recommended product in midseason. This is done by price concessions or other means to distributors, commercial applicators or large producers. The product may or may not succeed. Such practices destroy grower confidence in current recommendations. In contrast I suggest that such large scale introductions should only occur after consultation with proper government authority. If the situation warrants a midseason change in chemical recommendation, then added impetus would be given to the change by government approval, and above all producer confidence in both agencies would be maintained.

EXISTING EXTENSION ENTOMOLOGY SERVICES IN CANADA

I mentioned earlier that it is difficult to ascertain all of the extension entomology outlets in Canada. In general, forest extension entomology is handled by the various provincial forestry departments in co-operation and collaboration with the Forest Biology Division of the Canada Department of Agriculture. All entomologists at our various universities and colleges process numerous requests for information on a score of subjects. However, there seems to be no policy as to the nature or scope of such activity. The Division of Entomology, Ottawa, of the Canada Department of Agriculture contributes greatly to extension entomology through the medium of bulletins, circulars, press releases, and also through insect identifications by the Systematic Insect Unit. During the preparation of this paper I solicited and received facts and opinions from entomologists in every province of Canada, and it is from such information that I have compiled the following list of extension entomology services in each province.

1. Newfoundland, Prince Edward Island, and Saskatchewan have no provincial entomologists and extension entomology service is given by the Division of Entomology.

2. Alberta employs a Pest Control Supervisor who deals with plant insects and diseases, rat and coyote control. He is not an entomologist. They employ an entomologist in the Department of Health. The Science Service laboratory at Lethbridge employs an entomologist as Information Officer, dealing with both insects and diseases in Alberta.

3. A livestock insect extension entomologist, employed by Science Service and stationed in Lethbridge, Alberta, works throughout Alberta, Saskatchewan and Manitoba, with trips to B.C. on request.

4. Manitoba has recently appointed a Provincial entomologist - Provincial apiarist.

New Brunswick has a Provincial entomologist for crop insects only. Livestock insects come under the livestock branch.

6. Nova Scotia has a Provincial entomologist with two assistants. All teach as well as do extension entomology.

7. British Columbia has a Provincial entomologist with one assistant. They are engaged in all fields of entomology, except forestry.

8. Ontario has a Provincial entomology who works with fruit, nursery and general insects. In addition, five other entomologists deal with public health, vegetable and field crops, livestock and field crops, vegetables, and ornamentals. Chemical companies employ six entomologists in Ontario whose time is divided between insects, diseases, and weed control.

9. Quebec has a Provincial entomologist plus eight other entomologists who are primarily engaged in vegetable and fruit insect extension work.

Up to this point I have made little mention of the extension work being done at the various laboratories of the Division of Entomology, Canada Department of Agriculture. This does not mean that these laboratories are not doing considerable extension entomology. On the contrary, it is estimated by several

of these laboratories that from 5-45% of their staff's time is devoted to extension. I believe it would be fairly safe to state that in most of these laboratories an average of 15-20% of their time is devoted to extension problems.

RESEARCH INSTITUTIONS INVITE EXTENSION

While it has often been the expressed desire of many research workers to stay out of extension, such desire is often only lip service. There is a certain personal satisfaction and fascination from doing extension that many cannot bypass. I will agree that a small amount of extension by research persons is at times unavoidable, and at times desirable. Many claim they are forced into extension, yet make little, if any conscientious, concentrated effort to stay out of extension, or reduce their burden. I have several suggestions which might help those who honestly want to decrease their extension load.

1. Reroute inquiries to extension agencies. This reduces repeat business and points out the need for increased extension entomology services. I believe the appointment of information officers in some of the Science Service Laboratories should be regarded as a temporary arrangement, until the public have been educated to direct their inquiries to extension services. He cannot and will not perform all of the services required and desired of a Provincial extension entomologist.

2. Grower or producer meetings. Encourage requests for your attendance at such meetings to be routed through agriculture representatives, and extension entomology, if such exist. This will keep extension informed and tend to keep grower groups from coming to you direct with problems that could be handled by extension.

3. Research information. Keep extension informed often as to your research that is underway and as to its progress.

4. Extension aids. Photographs of new methods, equipment or test plots should be made available to extension.

5. Publications. Information service is providing publications on many of our insects. Some are good, many are only fair. Some are not worth printing from the extension viewpoint. They communicate little of value to the intended recipient, because they were not properly prepared for the ultimate user. I would suggest that prior to printing, such pamphlets be sent to existing local extension services for suggestions. It seems only right that an extension specialist should be consulted on the needs and manner in which printed matter can be of most use to the user of that information.

SUMMARY

In summary, and after taking cognizance of suggestions from across Canada, I would like to make the following observations. The need for increased extension entomology has grown during recent years and this trend will become more noticeable as research entomologists divorce themselves from extension. There has been a gradual recognition of the value of extension entomology and of the fact that special qualities, ability, and training are needed in good extension entomologists. The increased activity by chemical companies, with better trained men, in sales and service is a healthy growth. Research, industry, and extensoion collaboration must continue and strengthen for the mutual benefit of all. I would suggest that it would be in order and highly desirable, if we all made a careful analysis of the extension entomology facilities currently available in our respective provinces, and that the results of such an analysis be made known to proper authorities. I would further suggest a meeting of extension entomologists from the various provinces and the Entomology Division be called by the Chief, Entomology Division, at a fairly early date to discuss the whole extension entomology problem.

In conclusion I would remind you of a passage in the New Testament: Matthew 6 : 24 "No man can serve two masters: for either he will hate the one, and love the other; or else he will hold to the one and despite the other. Ye cannot serve God and Mammon". Gentleman, I suspect the same is largely true with research and extension.

ACKNOWLEDGMENTS

During the preparation of this paper, I solicited and received opinions and factual information from the following Science Service entomologists of the Canada Department of Agriculture: Dr. C. W. Farstad, Head, Crop Insect Section, Lethbridge, Alberta; Dr. H. McDonald, Entomology Section, Saskatoon, Saskatchewan; F. M. Cannon, Head, Entomology Section, Charlottetown, P.E.I.; R. F. Morris, Officer-in-Charge, Field Crop Insect Lab., St. John's Nfld. I received similar information from the following provincial officials; J. Andre Doyle, Chief, Division of Entomology, Quebec; H. W. Goble, Provincial Entomologist, Guelph, Ontario; D. R. Robertson, Provincial Entomolgist, Winnipeg, Manitoba; S. F. Clarkson, Director, Plant Protection and Promotion Branch, Fredericton, New Brunswick; M. E. Neary, Entomologist, Truro, Nova Scotia. I am most grateful to each of these men for the assistance they gave so willingly.

(*Accepted for publication*: *November 27, 1958*)

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TRENDS IN CANADIAN ENTOMOLOGY: INDUSTRY[1]

G. S. Cooper[2]

There exists today a tendency for industry to follow many differing trends in the pesticide field, each trend being directed largely by the individual company itself. There are, however, several major overall trends which can be generally cited after a careful study of the minor trends. I will attempt at this time to deal only with the broad general trends. As the industrial trends in the entomological field in Canada are closely related with those of the U.S.A., I will by necessity, have to lean heavily on information gathered from that country.

There is no doubt that one of the major changes which is taking place in the pesticide industry today is the realization of the importance of the role of the entomologist and the role that industry itself must play in maintaining the present high level of food production we have reached.

There is a general increase in interest and concern over the ever increasing numbers of incidents of resistance being reported. These can no longer be ignored. Once a resistance has been built up to a specific insecticide, there is a grave danger that resistance to the whole family of similar compounds is not too far distant. The problem then becomes just how many new families of compounds can be found with biological activity of sufficient magnitude to be worthy of further consideration. When this problem is combined with that of the one of finding a 'safe' insecticide the task becomes even more difficult.

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[1]Presented as part of a symposium on trends in Canadian entomology to the 95th annual meeting of the Society and the 8th annual meeting of the Entomological Society of Canada, Guelph, Ontario, October, 1958.

[2]Cyanamid of Canada Limited, Toronto, Ontario.

This fact has caused industry to look toward the possibility of utilizing mixtures of existing pesticides, mixtures of the newer compounds with the older ones whose use may have declined in the immediate past, or to the use of extenders. In the testing of extenders, use is being made of many of the homologues and analogues of existing insecticides in an attempt to ascertain whether or not they may be useful in helping to overcome resistance when added to the existing insecticide. While this last method is empirical, it is hoped that by the adding of an extender, a new block may be thrown in the metabolic pathway, or a greater penetration of the cuticle permitted, or even a hope that a metabolite of the extender may become toxic in itself. Industry is now well aware of this empirical approach and it is looking toward the enomologist to supply basic knowledge so that a more scientific approach may be made toward solving the problem. The lack of basic information from which to draw in guiding a research programme is becoming increasingly acute.

There is also a trend in industry today to give a great deal of thought to the question of whether chemical control as practiced today is the most desirable. Yields may be increased temporarily, but may we not, over a period of time, encounter pests which may be impossible to wipe out? Already 2% of the insect pests have shown power of resistance to commonly used pesticides. New resistance develops very rapidly. When one considers that extensive spraying is less than 20 years old, the number of cases of resistance is staggering. Not only is the resistance problem important, but also the creation of the basic imbalance between pest and predator and parasitizer is of growing concern. More and more industry is exploring the selective pesticide field. However, as the trend moves towards specialization, greater and greater numbers of chemicals and chemical combinations must be screened to find one that is marketable. Until such time as industry is able to predict exactly what a chemical, or combination of chemicals will do against any given pest or pests, under any given set of conditions, and until a greater wealth of fundamental information is available, progress will be limited to the results of the empirical approach and limited to bonds of one crop per year. The trend toward the attempt to find systemic insecticides has just begun. While several have appeared, they all have been limited by the lack of fundamental information. The trend toward the development of systemics will continue with the hope that the use of such a material will find a use which is acceptable to both those who follow chemical control and also those who follow the advantages of biological control.

There has been appearing recently another trend within industry itself which soon may make itself felt in this country. Many companies have already eliminated or have given serious thoughts to eliminating, their agricultural divisions and research sections. Some are remaining active only until they complete the work on chemicals already begun prior to the advent of the Miller Amendment, etc. It is a well-known fact that in 1956 the Agricultural Chemicals Industry returned a very low interest rate on investment income, while during the same year the average return on investment for the entire chemical industry was almost triple that of the Agricultural Chemical return. While much of this trouble may have been caused by the industry itself because of merchandizing methods, etc., it is getting more and more difficult to sell an agricultural research programme to a board of directors or a group of shareholders. This fact has already caused some companies to withdraw completely, and others to reduce their scope and expenditure in the pesticide field. The recent announcement that the cost per petition under the Miller Amendment had risen from $1,000.00. to $2,500.00. — 150% — will add to an already strained economy. The introduction of these new laws has increased developmental costs. It has increased many fold the paper work necessary. The development of analytical methods to establish residue tolerances has added substantial amounts as may be illustrated

by one producer, who reported that a cost of $250,000.00. per product was added when he was required to produce residue data. There has also been a great extension in some cases of the time lapse between the final development of a new product, its testing and its use by the consumer. In some cases, there is an increased reluctance on the part of university, governmental or extension workers to make recommendations to farmers about new products until they have studied and are familiar with all the residues, tolerances, etc. This delay often is reflected in an adverse manner when brought to the attention of a boards of directors when they are trying to decide where the next year's investments will be made. Why risk money in a field where cost is high, returns low and final acceptance in doubt, when investment in other fields is much more certain and returns higher?

In Canada as well as the United States, the law clearly outlines the standards industry must meet in developing a new insecticide. Members of the pesticide industry are keenly aware of their moral responsibility that no hazardous residues shall remain on or in food. The generally accepted residue is one that must not be more than 1/100th of the amount, if present in the entire normal consumption of food, that would have no effect on human health. While this may vary in some cases, the final tolerances allowed often curtails the extensive use of many pesticides and adds a great deal to the work which company research must do in order to get a 'safe' pesticide, which can be used to give protection up to harvest and even after harvest, if necessary.

In its research programme, the pesticide industry now realizes there are several important points which it must contend with: (1) lack of basic fundamental information to start with. (2) a great need for methods which will permit accurate predictions during screening stage of the chemical. (3) complete and exhaustive information of existing insecticides. (4) a more complete story of both harmful and beneficial insects. (5) how resistance builds up. (6) what materials will give control of those pests which at present we cannot control. (7) where and how to get better qualified people without competing directly with other agencies for the relatively few well-trained people now available. The pesticide industry is attempting to deal with all or some of these points in an effort to meet present pay demands.

There is also developing within the pesticide industry a desire to improve methods whereby a new pesticide, once developed, will be purchased and used by the grower correctly. A greater effort is being put forth to educate the purchaser in the need for and the correct use of new products. Attempts are being made to educate the dealer, the retailer, and finally the consumer, in order that correct use be made of pesticides and to prepare for the day that may arrive in the future, when highly toxic, narrow margin chemicals will have to be used to maintain high production. There are already in existence some chemicals which have not been released for use because of their toxicity and because application timing is so critical that they require a trained or educated operator for application. While these may never be needed, the day may come when they will have to be used if the empirical method of developing new insecticides is to remain our sole method of development.

A recent trend in Canada itself has been the ever increasing desire on the part of the pesticide industry to work more closely with Government agencies. From the initial testing to the final use by the consumer, co-operation is being sought. There is a trend toward the pooling of information and effort, and industry realizes and appreciates the contributions that can be made in this manner. It is hoped that this trend will not be slowed down by the introduction of new regulations which will increase the demands beyond those requested in the U.S.A. If such demands do extend too far beyond those in the United States,

there exists the danger that parent companies will withhold all new chemicals within their own borders until all experimental work has been completed. This I feel would be retrogression, and we in Canada would suffer. As the number of companies active in the pesticide field narrows, and as the willingness to co-operate increases, there is an ever brightening picture of both groups working in harmony. While many new pesticides may in the future be supplied by the European pesticide industry, we are still largely dependent upon the industries of North America to carry out a great deal of the work necessary in developing a new pesticide.

Research work in the pesticide field continues, some directed toward specific chemicals for specific insects, some toward a more broad spectrum insecticide. While industry would like to develop materials directed towards specifics, the economics involved in the necessity of using large numbers of specific insecticides, limits this field. To-date the dollar value of the crop to be protected, limits the amount that may be spent in this protection and when coupled with the cheapness of past protection the possibility of using specific sprays is never the brightest. When working toward a broad spectrum insecticide the problems of biological balance must be considered, and in the minds of many, the answer to a broad spectrum material will be finally be answered through the systemic field. It is every company's hope to achieve an acceptable insecticide, which when used correctly, will give control of all the insects we wish to control, and yet not harm those insects beneficial to mankind.

(*Accepted for publication: March 10, 1959*)

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III. SUBMITTED PAPERS

PRELIMINARY REPORT ON CONTROL OF THE BLACK CUTWORM, *AGROTIS YPSILON* (ROTT.), WITH ALDRIN INCORPORATED INTO THE SOIL IN VARIOUS WAYS[1]

J. A. BEGG AND C. R. HARRIS[2]

Work conducted at the Chatham laboratory (unpublished) shows that surface sprays of aldrin, dieldrin or heptachlor at 1.5 pounds, endrin at 0.66 pounds or DDT at 2.4 pounds per acre, harrowed into the soil before planting, control cutworms in tobacco in southwestern Ontario. Occasional failures of surface applications double-disked into the soil, and of insecticide-fertilizer mixtures drilled beneath the soil surface prompted comparison of different application methods.

This is a report on the effectiveness of aldrin incorporated in 1958 into a Berrien sandy loam soil in various ways at 1.7 pounds per acre against the black cutworm, *Agrotis ypsilon* (Rott.). The treatments were compared in plots of tobacco artificially infested with cutworms reared in the laboratory by the method of Harris, Begg, and Mazurek (3).

METHODS

The treatments (Table I) were tested in plots 30 feet square, arranged in a randomized-block design with four replications. The surface spray was broadcast in 50 gallons of water per acre to freshly-worked soil, and either spring-tooth harrowed one to two inches, or double-disked four to six inches into the soil within 30 minutes after spraying. The insecticide-fertilizer mixture was mixed in a Twin-Shell Dry Blendor (The Patterson Kelley Co., Inc., East Stroudsburg, Penn.), and broadcast on the soil surface with a fertilizer-grain drill, or drilled into the soil to depths of one to two, or three to four inches. The surface application was harrowed one to two inches into the soil within 45 minutes.

On June 30, one day after the plots were treated, 50 Delcrest tobacco plants were transplanted 15 inches apart in rows 40 inches apart, in a 15-foot square in each plot. The remainder of each plot served as a buffer area. The close-planting and wide buffer areas were intended as a means of reducing inter-plot movement of the cutworms.

Immediately after planting, 50 black cutworms in the late-third or early-fourth instar were introduced at random into the planted area of each plot except one of the untreated in each replicate.

Cutworm injury was assessed by examining each tobacco plant for feeding damage three, six, and nine days after the larvae were introduced. Injured plants were replaced after each examination because it is extremely difficult to distinguish between old and new injury.

Statistical significance of the data was determined by analysis of variance and the multiple range test (2).

RESULTS AND DISCUSSION

None of the treatments controlled the cutworms in the first three days after the plots were artificially infested (Table I). From the fourth to the sixth day, the surface treatments harrowed or disked into the soil allowed sigificantly fewer injured plants than the aldrin-fertilizer mixture drilled beneath the

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[1]Contribution No. 3932, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada; presented at the 95th annual meeting of the Society and the 8th annual meeting of the Entomological Society of Canada, Guelph, Ontario, October, 1958.

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surface. From the seventh to the ninth day, the surface treatments were more effective when harrowed one to two inches into the soil than when disked to a depth of four to six inches. Drilling the fertilizer mixture beneath the soil surface to a depth of one to two, or three to four inches did not protect the tobacco.

Table I

Mean percentages of tobacco plants injured during various periods after the black cutworm, *Agrotis ypsilon* (Rott.), was introduced into plots treated one day before transplanting with aldrin[a] mixed with the soil in various ways at 1.7 lb. per acre, Chatham, Ontario, 1958.

Form of application	Cultural practice	Depth in inches	Days after introduction 1-3[f]	4-6[f]	7-9
Insecticide[b]-fertilizer[c] mixture applied to surface	Harrowed	1-2	40.5[g]	17.5	2.0
Surface spray[d]	Harrowed	1-2	42.5	13.5	3.5
	Double-disked	4-6	43.5	15.0	7.0
Insecticide-fertilizer mixture	Drilled[e]	1-2	43.5	36.0	8.5
	Drilled	3-4	42.0	33.5	10.5
Check, artificially infested			58.0	38.5	10.5
Check, not artificially infested			34.0	35.0	11.0

[a]1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-*endo,exo*-5, 8-dimethanonaphthalene.

[b]5 per cent granular; Chipman Chemicals Ltd., Hamilton, Ontario.

[c]2-12-10 granular; Agricultural Chemicals Department, Canadian Industries (1954) Ltd., Chatham, Ontario.

[d]20 per cent emulsible concentrate; Chemical Division, Shell Oil Company of Canada Ltd., Toronto, Ontario.

[e]Applied with fertilizer-grain drill having drills 7 inches apart.

[f]Injured plants replaced.

[g]Data within same bracket do not differ significantly from each other at 5 per cent level.

These results indicate that soil treatments applied one week before planting a susceptible crop would give better protection against the black cutworm than treatments made immediately before planting. Experimental evidence of this was obtained at the Chatham laboratory in 1957.

The number of plants injured per day in the untreated plots decreased after the sixth day. This may have been partly the result of natural mortality of the cutworms and inter-plot movement of the introduced larvae. It is extremely doubtful that maturity of the larvae affected feeding as the durations of the fourth, fifth, and sixth instars of the black cutworm are about four, four, and five days respectively, in the field (1).

Wet weather during the experimental period may partially explain the differences in control by the various treatments. The cutworms burrowed just

beneath the surface of the wet soil during the daytime, and probably did not contact insecticide deposited at depths greater than one inch.

The apparent absence of cutworm injury in crops in the immediate vicinity of the experimental area indicated that introduced larvae were responsible for the high degree of injury in the plots that were not hand-infested. It was evident that a 15-foot buffer area between plots, and close-planting of the tobacco did not prevent the larvae from leaving the plots in which they were placed.

SUMMARY

Aldrin at 1.7 pounds per acre sprayed on the soil surface as a water-emulsion or applied in fertilizer, and cultivated or drilled various depths into a Berrien sandy loan soil, did not control an artificial infestation of the black cutworm, *Agrotis ypsilon* (Rott.), in flue-cured tobacco in the first three days after the plots were infested. During the next three days, the surface spray harrowed one to two inches or disked four to six inches, and the broadcast fertilizer mixture harrowed into the soil, allowed 18 per cent or fewer injured plants in comparison with 39 per cent in the untreated plots. From six to nine days, the surface treatments harrowed into the soil reduced injury from 11 per cent to 4 per cent or less. The surface spray disked into the soil was significantly less effective. The fertilizer mixture drilled one to two, or three to four inches into the soil provided no protection.

Close-planting the tobacco and 15-foot buffer areas of fallow land apparently did not prevent the cutworms from moving between plots.

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(*Accepted for publication: April 16, 1959*)

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INFLUENCE OF VEGETATION ON DISTRIBUTION OF WIREWORMS, *AGRIOTES* SPP., IN GRASSLAND: A PROGRESS REPORT[1]

C. J. S. Fox[2]

It is generally recognized that wireworms of the genus *Agriotes* are unevenly distributed in grassland. This uneven distribution has been attributed by various authors to the structure, pH, moisture, temperature, or humus content of the soil. Remarkably, it has rarely (4) been attributed to the kinds of plants present. Probably this is because, in general, wireworm injury to grassland is not obvious. This is a progress report on a study of the influence of several types of plants, including weeds, on distribution of the larvae within a field.

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METHODS

In 1953, a long-term study of a severe infestation of the European wireworm, *Agriotes sputator* (L.), was begun in a 60-acre field of old hayland near Digby, N.S. This field was approximately 350 feet above sea level. The soil was a brown shaly loam in a fair state of fertility, high in organic matter and with an average pH of 5.4. Twenty-four random samples of soil, 6 inches square and 8 inches deep, were taken at approximately monthly intervals from May to October for six years. The plant species on the surface of each sample were listed and the amount of foliage of each one inch above the soil, estimated to the nearest tenth of the sample area, was recorded; these readings were converted to percentage of foliage cover (3). The turf and soil were then broken apart and the soil was sifted through 1/4- or 1/6-inch mesh screen and the wireworms counted; by this method nearly all the larvae over 4 mm. long were collected.

RESULTS AND DISCUSSION

For brevity, several infrequent species of plants, and bare ground were omitted from the summary of results (Table I). As most samples supported more than one kind of plant, the number of larvae from each of these was placed in more than one category in the table. Analysis of variance showed that except for clovers, *Trifolium repens* L. and *T. pratense* L., and dandelions, *Leontodon autumnalis* L. and *Taraxacum officinale* Weber, the averages for the groups of percentages varied more than was to be expected from the variation within the groups. Therefore, on the whole, as the percentages of the following increased the number of larvae increased: wild carrot, *Daucus carota* L.; ribgrass, *Plantago lanceolata* L.; and grasses, chiefly *Phleum pratense* L. and *Poa pratensis* L.; conversely, as the cover of hawkweeds, *Hieracium* spp., increased the number of wireworms found declined. Thus the results suggest that the favoured habitats, in the order of declining abundance of larvae, are among the roots of wild carrot, ribgrass, grasses, clovers, dandelions, and hawkweeds. Observed association of larvae with the roots and laboratory tests suggested that this is also the order of food preference, although there were no signs that the hawkweeds were fed upon, either in the field or in the laboratory. But evidence of feeding restricted to fine roots would be difficult to see.

Table I

Average numbers of *A. sputator* larvae per 6-x6-x8-inch soil sample according to percentages of surface covered by various types of grassland vegetation, Digby, N.S. 1953-8.

Plant type	Percentage of surface covered by foliage					
	5-20	21-40	41-60	61-80	81-100	Total
Wild carrot	7.1±0.8[a]	9.0±0.9	11.7±2.2	8.8±2.1	14.0±3.1	51.6
Rib-grass	6.7±0.6	5.3±1.0	6.0±1.7	8.3±5.7	20.0±1.9	46.3
Grasses	6.2±0.4	6.0±0.5	7.6±0.8	7.2±1.4	16.0±2.9	43.0
Clovers	7.7±0.5	6.5±0.5	7.1±1.0	6.3±1.5	8.3±3.5	35.9
Dandelions	5.8±0.3	5.3±0.5	6.8±1.1	6.5±0.9	6.0±1.0	30.4
Hawkweeds	7.9±0.6	5.8±0.5	5.1±0.7	3.9±0.3	3.1±0.2	25.8

[a]Standard error.

Oviposition habits of beetles of the genus *Agriotes* have not been observed in nature, probably because this activity occurs at night. However, Gilyarov (2) showed that during the oviposition period beetles of the species *Agriotes obscurus*

(L.) and *A. lineatus* (L.) may prefer certain crops, being more common on rye, for example, than on flax; and Salt and Hollick (4) demonstrated a positive correlation between the density of *A. sputator* larvae and the percentage of perennial rye-grass in turf. Cohen (1) observed that clovers attracted fewer ovipositing beetles than did grasses.

The circumstantial evidence obtained in the present investigation, which, as relevant habits of wireworms have not been observed in nature, is as good as can be had without resorting to tagging methods likely to affect their behaviour, suggests that the site of an aggregation of larvae is determined, indirectly at least, by the influence of the vegetation on the ovipositing females. Since the adults feed sparingly, perhaps chiefly to obtain moisture, the important attracting factor may well be the amount of moisture at the soil surface, which is partly dependent on the density of the foliage, rather than an overruling response to specific plants or related groups of plants. That this is so is indicated by surveys of grassland in Nova Scotia infested by the wheat wireworm, *Agriotes mancus* (Say), which is more numerous in low-lying areas where the soil is more moist but where the composition of the vegetation is not perceptibly different from that of the higher areas. Little is known of the movements of *Agriotes* larvae, but Thorpe *et al.* (5) have shown that after hatching the larvae do not tend to leave a situation that provides desirable food but do tend to leave an undesirable situation and so chance upon more favoured food plants.

Thus the different components of grassland vegetation may cause uneven distribution of wireworms in soil in two important ways: (a) by influencing the site of oviposition and possibly the number of eggs laid, and (b) by influencing the site of feeding by larvae. The present data probably reflects the results of the two actions working jointly.

Use of pure stands would demonstrate more precisely the roles of different species of grasses and clovers in attracting and maintaining a population of wireworms.

ACKNOWLEDGMENT

The author wishes to thank Dr. E. C. Becker, Entomology Division, Ottawa, for critically reading the manuscript.

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(Accepted for publication: April 23, 1959)

EGG DEVELOPMENT, HATCHING, AND PREY TAKEN BY THE EUROPEAN MANTIS, *MANTIS RELIGIOSA* L., IN SEVERAL HABITATS[1]

H. G. JAMES[2]

Though the European mantis, *Mantis religiosa* L., has spread steadily throughout most of the agricultural land in southern Ontario since its introduction some 45 years ago, its numbers fluctuate widely, even in localities where it is well established. A scarcity of nymphs in midsummer usually reflects a high egg mortality. Low winter temperatures kill many of the eggs (3), but this does not account fully for the discrepancies between the numbers laid and the reduced numbers of ensuing adults. Because of their role as predators of injurious pasture insects, field populations of mantids were examined from 1943 to 1955 for factors in seasonal fluctuations in their abundance. The results, in part, form the basis of this paper.

METHODS AND MATERIALS

The investigation was centred in the Chatterton (Marsh Hill) district of Hastings County, Ontario. In 1943, information on the abundance of adult mantids was obtained by sampling the plant cover of a five-acre pasture with a sampling frame similar to that described by Smith and Stewart (4).

In 1949, nymphs and their potential prey were studied in a plot at the Sidney Field Station and also in a nearby flood-meadow. The flood-meadow, bordered by a small stream, had a high water table throughout the year and supported diverse ground cover of grasses, flowering plants, shrubs, and seedlings. The plot included about two acres of red top, *Agrostis alba L.*, of variable density, as well as other grasses. Commencing on June 8, 20 square-yard samples of the ground cover were examined weekly in each field with a sampling frame. Mantids and other Orthoptera found in the frame were counted and released. The same frame was used in October to determine the numbers of eggs laid.

In 1953, hatching was observed in the flood-meadow and also in two adjoining fields of a sandy, hillside pasture. Twenty-five marked oothecae were inspected each morning and afternoon from May 27 to June 24. All oothecae were collected on June 26 and dissected to determine the condition of the unhatched eggs.

The oothecae are deposited during the latter part of August until mid-October. At daily mean temperatures above 70° F. morphogenesis proceeds in eggs of the earlier oothecae until the embryos reach the gastrula stage and enter diapause. Eggs deposited in late summer, however, are subject to lower temperatures, which restrict or even stop growth of the embryos.

During the fall and spring of 1954-55, egg development was studied in three habitats: the flood-meadow, the sandy, hillside pasture already mentioned, and a drained pasture containing alfalfa and grasses. To obtain eggs, the fields were examined every second day during the egg-laying period, August 24 to October 18, and recently deposited oothecae were marked and numbered. Half of these oothecae (70) were collected on November 1 and the remaining half left to overwinter *in situ*. Approximately one-half of each ootheca collected was placed in storage at 1.1°C. and incubated in the spring. The cut end was sealed with melted paraffin to prevent loss of water. The remaining half of each was fixed in warm Bouin's fluid and the eggs were subsequently examined for embryonic

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development. Before the eggs were exposed for fixation, as much as possible of the surrounding matrix was removed from the ootheca. Damage to the eggs was lessened by gradually pulling apart the egg sections from the supporting lamellae and fixing each section separately.

The oothecae that had overwintered in the field were collected on April 12. One-half of each was fixed and beginning on May 6 the other half was incubated in the laboratory at 25°C. and a relative humidity of 55%.

The stages of the embryos were designated according to the growth of the germ band as embryonic rudiments, early gastrula, and mature gastrula. The earliest embryonic rudiment appears as a pale, circular disc on the ventral surface of the egg, almost two-thirds of the distance from the anterior pole. In a more advanced phase the disc is widened anteriorally to form either a U-shaped or a triangular plate. This is succeeded by the T-shaped early gastrula with distinct prothoracic lobes, and finally by the clearly segmented, mature gastrula. Unlike the eggs of certain grasshoppers which develop at a uniform rate in the pod (2), it is not unusual to find several stages represented in the same ootheca.

PRE-DIAPAUSE EMBRYONIC GROWTH

Owing to the difficulty of fixing the eggs, embryos were distinguished in only 18% from each habitat of a total of 5,793 collected on November 1. Three-quarters of the embryos consisted of embryonic rudiments, though eggs from the sandy hillside contained the least. Of the flood-meadow eggs, 82.8% contained embryonic rudiments, 17.2% early gastrulae, and none mature gastrulae. The corresponding figures for the drained pasture and the sandy hillside were 84.5, 14.0, and 1.5, and 76.8, 16.6, and 6.6, respectively. Apparently, lower temperatures caused by moist soil and denser plant cover prevented any embryos from reaching the mature gastrula stage in the flood-meadow.

POST-DIAPAUSE EMBRYONIC GROWTH

Post-diapause growth began about April 6, two weeks earlier than in 1944, and was well advanced on April 12. The most advanced embryos were found in eggs from the sandy hillside. Eighty-six point seven percent of these contained mature gastrulae, 3.5% early gastrulae, and 9.8% embryonic rudiments. The corresponding figures for the drained pasture and the flood-meadow were 21.3, 23.7, and 55.0, and 13.5, 14.6, and 71.9 respectively.

The advanced growth of the embryos from the sandy hillside appeared partly due to the earlier disappearance of the snow cover. Total snowfall for Stirling, four miles north of Chatterton, from December 15, 1954, to March 31, 1955, was 23.9 in., according to the Canada Department of Transport, Meteorological Division. Six to eight in. of snow remained in the drained pasture at Chatterton on March 3, and 8 to 10 in. in the other two fields. Toward the end of March there was still snow in the lower fields but none on the sandy hillside. Oothecae that overwintered in the field produced more nymphs and contained fewer unhatched eggs that those stored in the laboratory (Table I). From the former there was no significant variation at the 5% level between the hatch of eggs from the flood-meadow and that from the sandy hillside (F less than 4.2), or between that from the flood-meadow and that from drained pasture (F less than 4.05), or that from the drained pasture and that from the sandy hillside (F less than 4.0). It may be added that 20.5 to 26.2% of eggs that overwintered in the field and 24.4 to 29.1% of the laboratory-stored eggs produced nymphs that apparently were unable to emerge from the ootheca. Similar mortality was observed previously in the field as well as in the laboratory in 1953.

Table I
Percentages of eggs of *M. religiosa,* from three habitats, that hatched after overwintering in the field and in the laboratory

Origin	Where overwintered	Total	Percentage hatch
Flood-meadow	Field	772	59.0
	Laboratory[a]	361	38.2
Drained pasture	Field	2043	50.4
	Laboratory	1854	24.7
Sandy hillside	Field	1178	49.0
	Laboratory	1341	27.1

[a]Stored at 1.1°C. for five months.

HATCHING IN THE FIELD

Nymphs hatched from June 2 to June 16, a period that coincided with the earliest flowering of blue weed, *Echium vulgare* L. In spite of differences in elevation, exposure, and plant cover between the meadow and the sandy hillside, hatching commenced on the same day in each. Eclosion was observed only in the morning and at temperatures from 19° to 26° C., often in bright sunlight. The nymphs emerged slowly through openings in the top of the ootheca and eventually freed themselves from their embryonic envelope, the whole process taking three to five minutes. In one instance, all but four of 21 newly-hatched nymphs left the ootheca within 15 minutes, and 18 minutes later all had dispersed in the ground cover. Nymphs shortly after emergence often were found aggregated near the parent ootheca, presumably resting as the cuticle hardened. The presence of cast skins and disabled nymphs still attached to the ootheca was an indication of recent hatching, as these were removed usually by insect scavengers within a day or so, particularly if the egg mass was near the ground. As in the laboratory, nymphs from individual oothecae continued to emerge over a period of several days.

PREDATION BY ANTS

Two species of ants, *Formica lasioides* Emery and *Myrmica* sp., were predators of mantis nymphs. Workers of *Myrmica* sp. were frequently observed in the meadow examining egg masses and in two instances were seen to seize hatching nymphs. Nymphs were more open to attack on the sandy hillside where ant colonies were more numerous than in the other habitats, and where the egg masses were either deposited near the ground or dislodged from higher vegetation by grazing cattle or in some other way. One ootheca only nine inches from a colony of *F. lasioides* was subject to particular attacks: partially emerged nymphs were seized and quickly pulled out of the ootheca and carried off. Nymphs hatching from an egg mass near the ground were similarly captured by workers of *Myrmica* sp. In an adjoining field where most of the oothecae were attached to plant stems well above the ground nymphs were not attacked, though ants were almost as abundant.

This appears to be the first record of Nearctic species of ants attacking nymphs of *M. religiosa.* Ants were previously observed in this role by Fabre (1) in France.

OTHER PREDATORS

Egg masses near the ground, especially on the sandy hillside, were damaged frequently by field crickets. During September, holes were chewed in the sides of the oothecae and occasionally the entire egg pods were eaten. Another predator, a house wren, *Troglodytes aëdon* Vieillot, was observed feeding on a green nymph in a Belleville garden.

PREY OF *M. RELIGIOSA*

M. religiosa attacked any moving arthropod within striking distance of its powerful forelegs. Young nymphs in cages fed readily on aphids, leafhoppers, and small Diptera collected from mantis habitats. The larger nymphs and the adults devoured many Orthoptera and appeared to prefer soft-bodied insects such as *Acheta assimilis* F. and crickets of the genus *Nemobius*. The average longevity, number of prey eaten, and egg production of 24 caged adults that were fed grasshoppers, crickets, and flies (*Pollenia rudis* F.) in the laboratory are shown below:

Sex	Longevity (days)	No. of prey eaten daily	No. of oothecae laid
Males (7)	31.3	0.9	—
Unmated females (10)	48.2	1.8	0.5
Mated females (7)	70.7	2.1	1.3

The following additional prey records were obtained from casual observation in fields in Hastings County, Ontario, and indicate the importance of Orthoptera as food: Unidentified Acrididae, Foxboro, September 20 and 22, 1954; *Encoptolophus sordidus* (Burm.), Chatterton, August 29, 1946; *Acheta assimilis* F., Belleville, September 20, 1941, Chatterton, August 14, 1943, and Marmora, August 31, 1945; *M. religiosa*, Chatterton, September 17, 1954, and Foxboro, September 20, 1954; *Melanoplus bivittatus* (Say), Belleville, October 7, 1943; *M. mexicanus mexicanus* (Sauss.), Chatterton, August 12 (two records) and August 28, 1943, September 3, 1954, and Foxboro, September 27, 1954 (two records); *Nemobius* spp., Belleville, August 19 and September 4, 1942, Chatterton, September 29, 1943, June 29 and July 13, 1949, and Foxboro, September 20 and 24, 1954; *N. fasciatus fasciatus* (Deg.), Chatterton, August 22, September 10, 1943; *Acucephalus nervosus* Schr., Belleville, July 9, 1942; Muscidae, Chatterton, September 20, 1954; *Argiope trifasciata* Forskal., Chatterton, September 3, 1943.

Attempts to identify the remains of prey in the fore-intestine of field-collected mantids produced unsatisfactory results. The skeletal remains in the crop of young nymphs were so finely broken up that it was very difficult to recognize arthropod structures; often the crop appeared empty. The crops of older nymphs and of adults, however, contained relatively large sclerites, spiny appendages, eyes, mandibles, and sections of antennae and wings, of which some could be identified to order and family. The sclerites and appendages of crickets were frequently enclosed by a transparent film to form a smooth elliptical capsule. These capsules, 1.1 mm. long and from 0.2 to 0.4 mm. in diameter, were found both in reared and collected specimens.

Information on mantis prey was also obtained by sampling the plant cover in a five-acre pasture in Sidney Township that was a mantis habitat. A series of 20 square-yard samples was examined weekly from August 18 to September 19, and again on September 23. During this period field crickets were the most abundant Orthoptera though their numbers fluctuated considerably (Table II). Little change occurred in the mantis population except that caused by the addition of a few male immigrants, but there was a steady decrease in the number of other Orthoptera. In October, the number of mantis egg masses in 60 samples averaged 0.1 per square yard (range 0.03-0.38), a value not unusual from a habitat well populated with the mantis for several years. The large egg lay was attributed mainly to the abundance of crickets, a preferred food in the laboratory, and one prominent in the prey records.

Table II
Average numbers of *M. religiosa,* Gryllidae, and other Orthoptera per square yard in a pasture near Chatterton, 1943

Date	*M. religiosa*	Gryllidae	Other Orthoptera	Total Orthoptera
Aug. 18	0.1	4.9	3.2	8.2
Aug. 26	0.2	8.1	2.3	10.6
Sept. 3	0.1	6.3	1.6	8.0
Sept. 9	0.1	4.8	1.4	6.3
Sept. 23	0.15	5.4	0.6	6.2

The relative stability of the adult mantis population already noted was in marked contrast to the decreasing numbers of nymphs during the summer. This was particularly evident from samples taken in the flood-meadow and in a pasture at the Sidney Field Station in 1949. Though hatching was retarded somewhat in the meadow, nymphs were abundant in both fields in early June (Fig. 1). Their numbers soon decreased, however. At first, there were four to five times as many nymphs in the meadow as in the pasture, but their numbers decreased and during the ensuing 30 days this ratio lessened, and by August 11, when the nymphs had matured, there were approximately only twice as many.

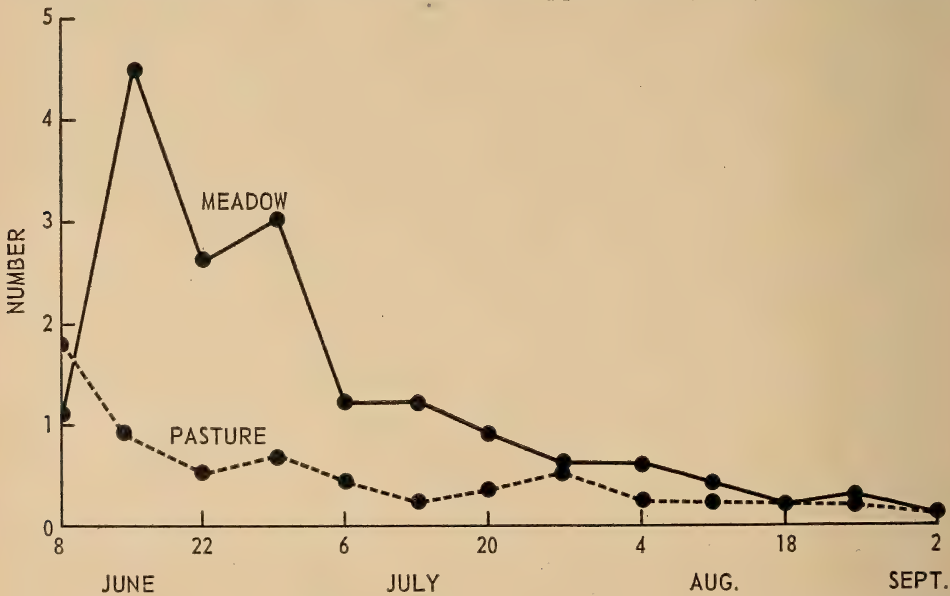

Fig. 1. Average numbers of nymphs of *M. religiosa* per square yard in weekly samples from two fields near Chatterton, 1949.

A variety of potential prey occurred in the samples. In the pasture, the larger specimens consisted of grasshoppers, crickets, muscids, and spiders, all of which became less common after July 6. In the meadow, plant bugs, and crickets (*Nemobius* spp.) were present during June; the latter were more numerous in July and were very abundant toward the end of August after the mantids had reached maturity. The numbers of oothecae in this field averaged 0.35 per square

yard as compared to 0.05 in the pasture. The egg masses in the meadow were also much larger than those in the pasture and apparently many of the mantids deposited more than one. Thus, in spite of the reduction in the number of early-instar nymphs, the older nymphs and the adults were able to subsist better in the meadow, where prey were more abundant than in the pasture. A habitat such as the meadow maintains the species locally and partly compensates for losses from low temperature, drought, and predators, sustained in other habitats.

SUMMARY

During 1953-54, in several habitats near Chatterton, Ontario, the development of eggs of the European mantis, *Mantis religiosa* L. in late autumn was more advanced in eggs on a hillside pasture than in those in a flood-meadow or in a drained pasture; this trend continued in the spring. There was no significant variation in the percentage of hatching, however, between the flood-meadow eggs and those from the other fields. Hatching in the three habitats observed occurred from June 2 to 17; small numbers of nymphs hatching from oothecae near the ground were destroyed by workers of *Formica lasioides* Emery and of *Myrmica* sp. The flood-meadow contained four to five times as many nymphs as did the field station pasture in June. This ratio was reduced to 2:1 at the end of the summer. Eventually more and larger egg masses were laid in the meadow, where prey were still more abundant. Rearing, dissections, and casual field records indicated that the adults and larger nymphs feed extensively on Orthoptera, especially field crickets. The abundance of crickets is important in maintaining the mantis locally.

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(Accepted for publication: June 4, 1959)

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RESISTANCE TO ALDRIN, DIELDRIN, AND HEPTACHLOR IN THE ONION MAGGOT, *HYLEMYA ANTIQUA* (MEIG.), IN ONTARIO[1]

R. J. McClanahan, C. R. Harris, and L. A. Miller[2]

From 1953 to 1957 damage by the onion maggot, *Hylemya antiqua* (Meig.), was effectively controlled in Ontario with 3 lb. to 5 lb. per acre of aldrin, dieldrin, or heptachlor in a preplanting broadcast application worked into the

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soil. Excellent control was also obtained when these insecticides were applied at 1 lb. per acre at planting time in row applications of dust or granules. Emulsible concentrates added to the formaldehyde solution used for smut control gave good control of the maggots and smut. Seed treatments were not widely used, although they were proved effective in some areas (4). Aldrin was used by most growers.

In 1958, however, severe infestations of the maggot occurred in many of the onion-growing areas. The onions were destroyed in fields that had been treated with aldrin at 2.5 to 10 lb. per acre in preplanting broadcast applications. Very large populations of adults were present from May to October. An unusual feature of the outbreak was that, in late fall, infestations developed in mature onions windrowed to dry before topping. Adults emerged from these onions in storage.

In the United States, strains of the onion maggot resistant to aldrin, dieldrin, and heptachlor were reported from areas where aldrin was used for four to six years. The resistant strains were recorded by Howitt (3) in the state of Washington in 1953, by Guyer (2) in one area of Michigan in 1956 and in all onion-growing areas of this state in 1957, and by Doane and Chapman (1) in Wisconsin in 1957.

This paper is a progress report on 1958 laboratory studies on onion maggot resistance to insecticides.

TESTS ON RESISTANCE OF ONION MAGGOTS

One hundred acres of onions are grown annually in the Dover Marsh, which borders the southeast shore of Lake St. Clair. In June 1958, large numbers of the maggots were found in a field where a preplanting application of aldrin at 3 lb. per acre had been used. Soil samples taken from this field on June 17, approximately two months after the application, averaged 2.2 lb. of aldrin per acre on analysis. Soil and maggot infested onions from this field were brought into the laboratory. Three replicates of 10 first-instar maggots were placed in 1-pint waxed cartons of the soil, each containing a small onion for food. There was no mortality within 48 hours, 90 per cent of the maggots pupated, and flies emerged from 81 per cent of the puparia.

Soil, previously untreated, was mixed in the laboratory with aldrin at rates equal to 3 and 6 lb. per acre. No mortality occurred at either rate within 48 hours in tests with 30 first-instar maggots in cartons of soil. Fifty-three and 70 per cent of the maggots pupated, and flies emerged from 78 and 70 per cent of the puparia in the respective treatments.

Large numbers of freshly emerged flies were observed in a field treated with aldrin at 5 lb. per acre. Up to 200 flies were captured in 50 net sweeps. Samples of soil from this field were placed in six 24-oz. cardboard cartons with 10 puparia in each. A total of 49 flies emerged from the 60 puparia, and only 7 flies died within 48 hours. In a comparative test using untreated soil, 55 flies emerged and none died within 48 hours.

TESTS ON RESISTANCE OF ADULTS

Since the preceding tests indicated that adults as well as maggots were resistant to aldrin, flies were tested for susceptibility to six insecticides commonly used against this insect. Large numbers of flies were collected from the Dover Marsh. In the Erieau Marsh, where there was no indication of resistance, only a few flies were found for comparison. Analytical or recrystallized insecticides were dissolved in a 9:1 acetone-olive oil solvent to give a series of concentrations from 0.001 to 1.0 per cent. The spraying was done in a Potter tower with 5-ml. aliquots of the spray, an air pressure of 15 cm. of mercury, and an exposure

period of 30 seconds. The flies were anaesthetized with carbon dioxide before spraying. The sprayed insects were kept 48 hours at 65° F. in clean cardboard cartons with a 2 per cent sugar solution for food.

Table I

Average percentage mortalities[a] of adults of the onion maggot from two areas in Ontario 48 hours after exposure in the laboratory to various concentrations of insecticides

Insecticide	Dover Marsh				Erieau Marsh			
	Concentration, %				Concentration, %			
	0.001	0.01	0.1	1.0	0.001	0.01	0.1	1.0
Aldrin[b]	17	9	11	19	13	95	100	100
Dieldrin[c]	28	21	17	64	15	100	100	100
Heptachlor[d]	0	0	10	15	—	—	—	—
Sevin[e]	5	0	95	100	5	25	95	100
DDT[f]	0	10	100	100	75	65	100	100
Korlan[g]	35	100	100	100	—	—	—	—
Diazinon[h]	0	100	100	100	—	—	—	—
Parathion[i]	10	100	100	100	—	—	—	—
Methyl parathion[j]	65	100	100	100	—	—	—	—

[a]Mortality figures are the average of 2 replicates of 10 flies.

[b]1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-*endo,exo*-5,8-dimethanonaphthalene, 100 per cent recrystallized; Shell Oil Co. of Canada, Toronto, Ont.

[c]1,2,3,4,10,10-hexachloro-*exo*-6,7-epoxy - 1,4,4a,5,6,7,8,8a-octahydro-1,4- *endo, exo*-5,8-dimethanonaphthalene, 100 per cent recrystallized; Shell Oil Co. of Canada, Toronto, Ont.

[d]1 (or 3a),4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene, 99.3 per cent analytical; Velsicol Chemical Corp., Chicago, Ill.

[e]N-methyl, 1-naphthyl carbamate, 100 per cent recrystallized; Union Carbide Chem. Co., White Plains, N.Y.

[f]1,1,1-trichloro-2,2-bis (p-chlorophenyl)ethane, 100 per cent recrystallized; Geigy Chemical Corp., Yonkers, N.Y.

[g]*0,0*-dimethyl *0*-2,4,5-trichlorophenyl phosphorothioate, 99-100 per cent analytical; Dow Chemical Co., Midland, Mich.

[h]*0,0*-diethyl *0*- (2-isopropyl-6-methyl-4-pyrimidyl) phosphorothioate, 100 per cent recrystallized; Geigy Chemical Corp., Yonkers, N.Y.

[i]*0,0*-diethyl *0-p*-nitrophenyl phosphorothioate, 99.6 per cent analytical; American Cyanamid Co., New York, N.Y.

[j]*0,0*-dimethyl *0-p*-nitrophenyl phosphorothioate, 96.7 per cent analytical; Nutritional Biochemicals Corp., Cleveland, Ohio.

Table 1 indicates that flies from the Dover Marsh were resistant to aldrin, dieldrin, and heptachlor. They were moderately susceptible to Sevin and DDT, and susceptible to the phosphate insecticides tested. The Erieau flies were susceptible to aldrin and dieldrin and moderately susceptible to Sevin and DDT. It is evident that a resistant strain was not present in the Erieau area in 1958.

DISTRIBUTION OF RESISTANT STRAINS

The onion-growing areas in Ontario and Quebec where resistant strains had developed by the fall of 1958 were determined by spraying flies from different areas with aldrin. Puparia collected in the fall from 9 areas were stored at 40° F. for a month, and then placed at 80° F. for adult emergence. Two-day-old flies were tested with various concentrations of aldrin; the same techniques were used as in the preceding tests. Only 100 insects from each area were used. The tests clearly separated resistant and susceptible populations: at a concentration of 0.1 per cent aldrin the mortality ranged from 20 to 50 per cent in flies from resistant populations, whereas it was 100 per cent in flies from susceptible populations.

The tests showed that resistant strains were present in the onion-growing areas of Bradford, Dover Marsh, Islington, La Salle, and Thedford in Ontario and Ste. Clothilde in Quebec, but not in the Erieau Marsh in Ontario or the St. Jean or Rougemont area in Quebec. These findings confirmed field observations made during the summer.

SUMMARY

In 1958 heavy infestations of the onion maggot caused severe damage in fields in Ontario that had been treated with aldrin or dieldrin before planting. In laboratory tests, 81, 37, and 85 per cent of adults from an area where aldrin had been used for 5 years, survived 1.0 per cent sprays of aldrin, dieldrin, and heptachlor, respectively. No adults from an area where aldrin had been used only 3 years survived 0.1 per cent sprays. Korlan, Diazinon, parathion, and methyl parathion gave 100 per cent mortality of flies from both areas at concentrations of 0.01 per cent. Resistant strains of the onion maggot were found in all the major onion-growing areas in Ontario except Erieau Marsh, and in the Ste. Clothilde region of Quebec.

ACKNOWLEDGMENTS

Onion maggot puparia were submitted for research by Mr. P. Perron, Research Laboratory, St. Jean, Que.; Mr. H. Goble, Ontario Agricultural College, Guelph, Ont., and Mr. R. Chard, Ontario Department of Agriculture, Forest, Ont. Technical assistance was given by Mr. J. H. Mazurek.

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(*Accepted for publication*: *April 28, 1959*)

SYSTEMATICS OF *NEODIPRION* SAWFLIES. I. PRELIMINARY REPORT ON SEROLOGICAL AND CHROMATOGRAPHIC STUDIES[1]

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INTRODUCTION

In recent years a number of new or relatively new laboratory procedures, among them serological and chromatographic techniques, have been applied to the study of a variety of entomological problems. Paper partition chromatography in particular has been widely used; although serological techniques are older, they have not been as widely applied, at least in Canada.

Insect systematics is one of the fields in which it would appear that a wider application of these techniques might be valuable. Such systematics studies as have been made to date have been for the most part either very broad or of somewhat limited scope, and to our knowledge no application of a combination of these techniques has been made.

Using one-dimensional paper chromatography as a tool, Robertson (18) showed interspecific differences in ninhydrin-positive and fluorescent spots among 17 species of insects representing four orders. Auclair and Dubreuil (1) used two-dimensional paper chromatography to separate nine species of insects representing four orders. Micks and Ellis (11) recorded the free amino acids in seven species of mosquitoes involving four genera. Ball and Clark (2) studied the species differences in three species of *Culex* mosquitoes. The application of paper chromatography to problems in insect taxonomy has been discussed by Micks (10) and others.

The use of serological techniques in systematics dates from the time of Nuttall (12) who first suggested their application to the classification of animals. Leone (7, 8) used serological procedures to study the systematic relationships among certain Orthoptera. Lawlor (6) combined complement fixation and precipitin test techniques for a comparison of five species of mosquitoes.

Up to the present there has not been a wide acceptance by systematists of the use of what may be classed as biochemical procedures. (Since this manuscript was first prepared Brown (4) has discussed taxonomic problems with closely related species and in reference to biochemical methods says ". . . it is too early to judge their usefulness in the study of closely related species.")

The objective of the present study is to provide a concrete demonstration of the value and limitations of serological and chromatographic techniques. This we propose to do by applying them in sufficient detail to a problem of sufficient scope so as to indicate their usefulness to the systematist. This paper is presented as an initial report to call attention to work in progress and to invite critical comment and cooperation. For that reason we are not at present concerned with a detailed review of pertinent literature nor with detailed reporting on incomplete studies.

The choice of *Neodiprion* sawflies was made on the basis that:

1. The group includes a number of economically important forest insect pests.

2. It is one with which systematists have been actively concerned in recent years.

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[1]Contribution from the Department of Biology, Queen's University, Kingston, Ontario. These studies have been supported by the National Research Council, the Ontario Research Foundation, and the Committee on Scientific Research, Queen's University.

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3. Whereas the relationships among some members of the group appear to be established, there are lacunae which preclude a complete understanding of the systematics of the group.

4. The study can be expanded to involve other genera and families of sawflies.

5. Larval collections can be secured through cooperators.

Six species secured during the past three summers are *Neodiprion lecontei* (Fitch), *N. sertifer* (Geoff.), *N. nanulus* Schedl, *N. swainei* Midd., *N. pratti banksianae* Rowher, and *N. virginianus* complex. In Ontario the *virginianus* complex probably includes only one species formerly designated as *rugifrons* Midd.

We wish to emphasize that the worker using serological, chomatographic or other techniques on a problem such as this one need not be a systematist. Rather, he can without bias develop information which can then be made available to the specialist. In the present work in order to avoid any bias, none of us has read, for example, Ross' (19) paper on the taxonomy and evolution of the sawfly genus *Neodiprion*.

MATERIALS AND METHODS

This study is based on a comparison of larvae of the various species. With the exception of *N. lecontei,* all collections of sawflies used to date have been furnished through the cooperation of personnel of the Forest Insect Survey, Forest Biology Division, Research Branch, Canada Department of Agriculture[1].

Sawfly larvae were collected in the field and shipped to Kingston with foliage on which they were found. With few exceptions collections have consisted of mature larvae, and in most shipments at least a few larvae had already formed cocoons. Cocoons were separated and larvae were removed from foliage, placed in a cage and starved for 48 hours at room temperature. This procedure was adopted to reduce possible contaminating gut contents. Samples of all collections have been preserved to permit a check on identification as submitted by the collector.

Starved larvae were weighed and either deep-frozen for subsequent extraction or extracted at once. All serological and chromatographic tests have been made with extracts of larvae prepared in the following manner. To each one gram of larvae was added 4 ml. of buffered (pH 7.0) physiological saline, merthiolated 1:10,000. Protein nitrogen determinations showed that this volume-weight ratio gave the highest protein yield, presumably desirable for antigenic purposes. Larvae in saline were placed in a blendor and homogenized for two one-minute periods to avoid overehating and possible denaturing effects. The mixture was allowed to extract in the cold (approximately 4°C) for an arbitrarily selected period of 48 hours. The mixture was then filtered, centrifuged, Seitz-filtered and bottled under sterile conditions. Prepared extracts are held at 4°C or can be deep-frozen. Sterility of refrigerated extracts is tested periodically.

Serological Techniques

All antisera have been produced in rabbits. Whole extract and extracts treated in several ways have been used. During the past year most consistent results in terms of avid, high-titred antisera have been secured by preparing a tannic acid-precipitated antigen and giving three 1-ml. subcutaneous injections on alternate days. Trial bleedings are taken 7-10 days after the final injection. If the titre is satisfactory (1:1000 or higher) the rabbit is exsanguinated and the serum separated, Seitzed, bottled and frozen until required.

[1]We are particularly indebted to Drs. B. M. McGugan, W. L. Sippell and L. Daviault.

Serological comparisons are made by the use of a Libby (9) photronreflectometer (a nephalometer), and the entire range of reaction of an antiserum with various dilutions of a homologous or heterologous antigen is measured after the technique of Boyden and De Falco (3). From the turbidimetric readings obtained, a curve is plotted (turbidity against dilutions of antigen extract). A homologous reaction will always give an area under the curve greater than that for a heterologous reaction. The heterologous antigen most closely related to the homologous will give the area closest to the homologous curve area, and the most distantly related heterologous antigen will produce the smallest area under the curve. According to the method of Boyden and co-workers at Rutgers University (loc. cit.), the homologous area is taken as 100 and the heterologous curve areas are expressed as percentages of 100. These figures indicate serological correspondence but in themselves have no absolute meaning. Another antiserum to the same antigen, produced in a second rabbit, may give a homologous curve of greater or lesser area, or of different shape, and heterologous curves whose area-percentages differ widely from those obtained with the first antiserum. However, the order of placement of a group of heterologous species will remain the same. The principle involved is a well-established one that an antiserum made to a protein will react more strongly with *that* protein than with any other. Any other protein reacting with this antiserum will do so in proportion to its biochemical correspondence.

In addition to photronreflectometer tests, several serum-agar tests have been tried, including Oudin's (15) tube technique, Ouchterlony's (14) petri dish technique and Ransom's (17) comparator cell test. In all of these except the double-diffusion technique, antiserum is mixed with agar and antigen is allowed to diffuse into the mixture. As the name implies, antigen and antibody diffuse into the agar from opposite directions in the double diffusion technique. As diffusion proceeds, bands of antigen-antibody complex precipitates form. The number of bands gives an indication of a minimum number of antigenic components present and a homologous antigen-complex will produce more bands than a heterologous antigen. Thus, this technique offers another way of securing an indication of serological correspondence.

Chromatographic Techniques

Two-dimensional paper partition chromatography has been used to study the fluorescent compounds and ninhydrin-positive compounds present in extracts of sawfly larvae. Washed No. 1 Whatman filter papers ($18\frac{1}{2}$ x $22\frac{1}{2}$") were spotted with $40 \mu l$ of the extract ($5 \mu l$ at a time) to be run. Preliminary tests established this quantity as optimum. The first run, along the long axis of the paper, was in phenol for 17 hours at $27 \pm 1.5°C$. Papers were dried for 24 hours and the second run was made, along the short axis of the paper, in butanol-acetic acid-water for 30 hours at $27 \pm 1.5°C$.

Following the completion of the second run, the papers were dried for a minimum of 3-4 hours, baked in a chamber at 65°C for 15 minutes and examined under both long and short-wave ultra-violet light. Any fluorescent areas were outlined in pencil. The papers were then sprayed with 1 per cent ethanolic ninhydrin solution and again baked for 15 minutes. All papers were examined on a viewer at a standard interval after baking. Coloured spots were outlined in pencil. Developed papers were compared with a standard amino acid map prepared under the same conditions. Clearly identifiable amino acids were labelled. Where doubt as to the identity of the amino acid existed or an obvious "unknown" was present, a number was assigned. Sufficient replicates were run to ensure that a standardized technique was being used.

RESULTS AND DISCUSSION

Serology

To date, antisera to four species of sawflies have been prepared. Because of limited amounts of extract, it has not been possible to make all possible heterologous comparisons. Examples of percentage relationships as indicated by a study of four antisera are shown in Table I.

Table I

Antigen	Antisera			
	sertifer	*nanulus*	*lecontei*	*banksianae*
sertifer	*100*	41	40	51
virginianus	90	69	—	63
nanulus	54	*100*	57	—
lecontei	50	73	*100*	58
banksianae	46	47	39	*100*
swainei	33	28	9	—

Table I shows that when anti-*sertifer* serum is reacted with heterologous extracts, *virginianus* antigen reacts most strongly and *swainei* antigen least. Thus *virginianus* is more closely related to *sertifer* and *swainei* is most distantly related. *Nanulus, lecontei,* and *banksianae* fall in between. In addition to realizing that the figures have no absolute value, it is important to recognize that the figures in a vertical column show order of placement in relation to for example, *sertifer* (1st column) but not to one another. *Nanulus* 54 and *lecontei* 50 does not necessarily mean that these two species are closely related, as is evident from an inspection of the results obtained in tests with antisera to these two species.

It helps to keep in mind that a phylogenetic tree is not on a flat plane but is three-dimensional. Two species may be equi-distant from a third species in two directions. When all possible reciprocal tests have been completed (antisera to all species run against antigens of all species), it will be possible to construct a three-dimensional model which will give a fairly accurate picture of the relationships of all species to each other.

Limited serum-agar tests have been run. It was found that the double diffusion technique of Oakley and Fulthorpe (13) gave the clearest separation for the antigen-antibody systems tested. For tests of the several serum-agar techniques, anti-*sertifer* sera were run against *sertifer, virginianus* and *banksianae* antigens. Again it was evident that *virginianus* is more closely related to *sertifer* than is *banksianae*. Eleven antigenic components (bands) were found in *sertifer* extract; in the heterologous tests *virginianus* extract produced six bands and *banksianae* extract four.

In view of the objective of this study, we feel that a more detailed consideration of the serological results to date is not warranted at the present ime. The aim of this preliminary report is to show the kind of information that is being developed.

Chromatography

Chromatograms of free amino acids and other ninhydrin-positive compounds and fluorescent compounds have been run from extracts of all six species of sawflies. A minimum of four replicates was set as a standard in these

preliminary tests. Replicates gave uniform patterns. A total of 30 spots has been recorded, not all represented for all six species. Since little confirmation of identity has been done to date, most spots are designated by number. Table II lists the compounds which were not present in all species and thus may indicate a species specific pattern.

Based on the presence or absence of certain compounds, it is possible to prepare a key to the six species. Although this key is valid for the material examined, its presentation as a species key is not justified at this stage. We wish

Table II
Presence of some ninhydrin-positive spots and fluorescent spots on chromatograms of *Neodiprion* species

Spot	Species					
	sertifer	*virginianus*	*lecontei*	*banksianae*	*nanulus*	*swainei*
Ninhydrin-Positive						
N-1	±	−	±	+	+	+
N-2	−	−	+	+	+	+
N-3	±	±	−	+	+	+
N-4	−	±	±	+	+	+
N-5	−	−	+	+	+	+
N-6	±	−	+	−	±	−
N-7	±	−	+	±	±	±
N-8	±	−	−	−	−	±
N-9	−	+	+	+	+	+
N-10	−	−	−	−	+	+
N-11	−	+	−	−	−	−
Fluorescent						
F-1	−	−	−	+	±	−
F-2	−	−	−	+	−	−

± trace quantities

to emphasize that whereas results of serological tests are definitely valid, the results of these initial chromatographic tests are open to conjecture. It must be borne in mind that chromatograms were prepared from extracts which represented a blending of usually hundreds of larvae. In all larval populations there would be some spread in development; newly molted larvae, larvae ready to molt and larvae ready to spin cocoons would be included. It is necessary to examine the validity of chromatograms of such pools and to bear in mind that ideally it would be desirable to be able to use this technique to identify individual insects.

The pooling of sera of individuals is standard procedure in serological studies. Although changes in the blood antigens of insect larvae do occur during development (20), such changes do not obscure "common denominator" antigens which are present throughout larval development as shown by our own unpublished studies.

In contrast with serological work there is reason to expect that, when chromatography is being used to separate individual amino acids (and other ninhydrin-positive compounds), considerable variation, certainly quantitative and possibly qualitative, might be encountered among individual larvae or extracts of one species from several sources. Robertson (18), for example, found that differences in one-dimensional patterns existed between first and third

instars of *Pristiphora erichsonii* (Htg.). He also showed that the sex of *Aedes aegypti* L. pupae could be distinguished. Fox (5) obtained different chromatograms from male and female *Drosophila.*

On the other hand Robertson was not able to distinguish geographic isolates of *Malacosoma disstria* Hbn. or of *Chamaepsila rosae* (F.) (Diptera; Psilidae), nor physiological entities of first and third instar larvae of *P. erichsonii.* Ball and Clark (2) obtained the same amino acid pattern for *Culex quinque fasciatus* Say from southern California as had been found for this species in Texas.

To date, chromatograms have been run only of extracts of single collections of each species. In order to examine possible variables, we have made a number of collections of *N. lecontei.* These will enable us to compare individual larvae of a clone, larvae from different clones in one pine stand, larvae collected in three areas during one season, larvae collected during three seasons in one area and larvae fed on red, white, scotch and jack pine. In addition for some collections we have newly spun cocoons as a source of a standard-aged larva. Examination of this material has just been started. It is recognized that the absence of a particular compound may only mean that it is not present in sufficient quantity to be detected by the techniques being used. Pratt and Auclair (16) have shown that there is a considerable variation in the minimum quantity of amino acids required to give a ninhydrin reaction.

(Since this manuscript was prepared sufficient work has been completed to show that both quantitative and qualitative variation in ninhydrin-positive compounds occur among individual larvae of some of the collections listed above. It is apparent that a more detailed and more extensive study is required and that in future work particular attention must be paid to age of larvae.)

With the availability of serological techniques the chromatographic studies may appear to be needless, but serology has one major disadvantage. Collection of material in sufficient quantity for antigen preparation for injection of rabbits and use in tests is necessary. For example, our standard request is for a minimum of 1000 mature larvae and such numbers are not always readily obtained. With small numbers, only heterologous tests can be run. In contrast, chromatography would appear to offer a possible technique whereby small numbers of larvae may suffice.

This project is a long-term one and it is intended that study will be continued over a period of years with the gradual accumulation of serological and possibly chromatographic evidence on the systematics of *Neodiprion* sawflies. At the Sault Ste. Farie Forest Insect Laboratory, collections of larvae which appear to be different from yet related to recognized species are being frozen for subsequent examination in our laboratory. Other sources will be welcomed.

SUMMARY

1. Six species of *Neodiprion* sawflies are being examined to provide an adequate demonstration of the value of serological and chromatographic techniques to the systematist.

2. Antisera produced in rabbits can distinguish the six species, and it is possible to secure an indication of degrees of relationship. *N. virginianus* is most closely related to *N. sertifer* and *N. swainei* is most distant.

3. Species distinctive patterns of ninhydrin-positive compounds and fluorescent compounds have been produced by two-dimensional chromatographing of extracts of sawfly larvae. The validity of these distinctions is being examined.

ACKNOWLEDGMENTS

Appreciation for laboratory assistance is expressed to Mrs. Shizuye Faulkner, Mr. Clifford Derry and Mr. Robert Robertson. We are particularly grateful to Dr. R. J. De Falco, Serology Museum, Rutgers University, for numerous suggestions and for a review of some of our results.

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(*Accepted for publication*: *June 12, 1959*)

IV. SCIENTIFIC NOTES AND COMMENTS

NOTES ON HOST PLANTS OF THE CARROT RUST FLY, PSILA ROSAE (F.), IN THE HOLLAND MARSH, ONTARIO, CANADA[1]

H. ELDON SCOTT[2]

The carrot rust fly, *Psila rosae* (F.), has been recorded in the larval stage from some fifteen species of plants, most of them being vegetables (Table I).

Table I
Host plants of the carrot rust fly, showing the earliest known records, the observers, and the countries where the records were made.

Plants	Country	Observers[a]	Year
Beet	United States	MacLeod (6)	1929
Caraway	Holland	Goedewaagen (5)	1926
Carrot	England	Curtis (3)	1829
Celeriac	Canada	Fletcher (4)	1904
Celery	England	Major (7)	1829
Chevril[b]	England	Petherbridge (10)	1942
Coriander	United States	Webster (15)	1937
Dill	Sweden	Tullgren (14)	1917
Fennel	United States	Webster (15)	1937
Hemlock (*Conium* sp.)	England	Petherbridge (10)	1942
Parsley	Sweden	Tullgren (14)	1917
Parsnip	England	Ormerod (8)	1877
Potato	United States	Pettit (11)	1931
Rape	Austria	Schiner (13)	1864
Turnip	Austria	Schiner (13)	1864
Wild carrot	United States	Crosby & Leonard (2)	1918

[a]The numbers in parentheses refer to the references listed under "Literature Cited".
[b]Adult flies.

Peairs (9) stated that all cultivated and some wild umbelliferous plants are attacked. Most other workers, however, were more specific. Whitcomb (16) listed carrots, celery, parsley, parsnips, celeriac, fennel, coriander, caraway, and dill as hosts. He noted that carrots, celery, parsley, and parsnips were the preferred host plants. Wild carrots, carrots, and potatoes were listed by Pettit (11). He believed that wild carrots acted as a reservoir from which the pest spread to cultivated crops. MacLeod (6) listed beets also as a possible host plant in Pennsylvania.

In Sweden, the carrot rust fly was reared from turnips and rape, according to Chittenden (1). Schiner (13) also listed turnips and rape as host plants.

Petherbridge (10) found that in England the adults frequented the blooms of chevril. The writer noted the adults on flowers of caraway and wild carrot, but could not determine if they were just resting or feeding on pollen or nectar.

In the Holland Marsh area of Ontario, previously described by Salkeld and Scott (12), roots of wild carrots, wild and cultivated caraway, turnip, potato, fennel, celeriac, and anise from heavily infested areas were examined during the years 1948-52 without noting any injury caused by the carrot rust fly. Roots of water hemlock had slight injury that might have been caused by this pest. Roots of carrots, parsnips, celery, parsley, and dill in the Holland Marsh area were favorite hosts of the carrot rust fly.

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[1]The work reported herein was carried out in partial fulfilment for the degree of Doctor of Philosophy, Cornell University, Ithaca, N.Y., while the author was employed by the Canada Department of Agriculture, Ottawa, and the Ontario Agricultural College, Guelph, Ontario.
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(Accepted for publication: May 25, 1959)

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NEW RECORDS OF THE EUROPEAN MANTIS, MANTIS RELIGIOSA L. (ORTHOPTERA: MANTIDAE), IN ONTARIO[1]

H. G. James[2]

The occurrence of the European mantis, *Mantis religiosa* L. since its appearance in the province of Ontario some 50 years ago was reported by James (1), Judd (2), and Urquhart and Corfe (3). Additional records were obtained in a survey in the Ottawa district and in the counties of Hastings, Muskoka, and others bordering southern Georgian Bay, Lake Huron, and Lake St. Clair in 1955 and 1956. Suitable oviposition sites in these areas were examined in early October and each searched for 45 minutes.

Egg masses were found in 17 of 50 sites, as follows: Almonte, Carleton Place, Carp, Clinton, Coldwater, Collingwood, Elmvale, Exeter, Kincardine, Lafontaine, Meaford, Midland, Owen Sound, Penetanguishene, Southampton, Wiarton and Wingham. Most of the oothecae were on grasses, particularly timothy and couch grass, though some were found on fences and other wooden structures. At none of these points, however, were they abundant. In the Ottawa valley, no oothecae could be found in many fields suitable for oviposition, at Kinburn, Arnprior, Fitzroy Harbour, Renfrew, and Pembroke. Similarly, none was found in the Bancroft district of Hastings County or in Muskoka.

The above records serve to indicate that the mantis now occurs in virtually all sections of continuous agricultural land in southern Ontario.

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(Accepted for publication: December 31, 1958)

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V. REVIEWS AND REPORTS

SUMMARY OF IMPORTANT INSECT INFESTATIONS, OCCURRENCES, AND DAMAGE IN AGRICULTURAL AREAS OF CANADA IN 1958[1]

C. GRAHAM MACNAY

This summary of insect conditions in Canada in 1958 was prepared from regional reports submitted by officers of the Entomology Division, provincial entomologists, officers of the Plant Protection Division, Canada Department of Agriculture, and university professors. In general, common names used are from the 1955 revision of the list approved by the American Association of Economic Entomologists. To avoid unnecessary duplication, forest insect conditions are not included, this being adequately dealt with in the *Annual Report of the Forest Insect and Disease Survey,* published by the Forest Biology Division, Canada Department of Agriculture.

GENERAL-FEEDING AND MISCELLANEOUS INSECTS

BEET WEBWORM.—In British Columbia the beet webworm was a minor pest. In Alberta the greatest infestation in 20 years caused severe damage to sugar beets, necessitating the spraying of the entire 38,000-acre crop. Peas were attacked for the first time. Some 35,000 acres of flax, mustard, safflower, and sunflower were sprayed and damage occurred in many cereal crops. In Saskatchewan, too, the population was the largest in 20 years. The greatest damage occurred in rape, but flax and safflower also were attacked. The heaviest infestations were found in the Fox Valley—Tunstall, Unity-Cutknife, Humboldt-Melfort, and Yorkton areas, populations on rape ranging up to 150 larvae per sq. ft. In southern Manitoba the outbreak was the most severe in the Province's history of sugar-beet growing. Over 20,000 acres were sprayed, but control was variable. Sugar beets and garden crops were attacked in June and early July in south-central regions, but later the insect became numerous on other crops farther north and west, notably flax, sunflower, rape, and alfalfa, 20,000 acres of flax being treated with insecticide.

BLISTER BEETLES.—In British Columbia, *Epicauta oregona* Horn caused minor damage to alfalfa at Kamloops and to potatoes at Midway. In Saskatchewan, *Lytta nuttallii* Say occurred in the largest numbers since 1952 and attacked broad beans, sweet clover, vegetables, and caragana. In Manitoba, larvae of several species were commonly observed when soil was sifted for grasshopper eggs. In Quebec, *Epicauta pennsylvanica* (DeG.) occurred in small numbers in the St. Anne de la Pocatiere area.

CRICKETS. — In Manitoba the Mormon cricket was scarce, but the field cricket was numerous wherever grasshoppers were abundant. In eastern Ontario and southern Quebec, the field cricket was more numerous than in 1957, but of minor economic importance. Populations in Prince Edward Island were small.

CUTWORMS.—On Vancouver Island and in the lower Fraser Valley, B.C., the variegated cutworm occurred in the most widespread and severe outbreak on record. On the Island, strawberry, potato, and tomato were severely demaged. At Vancouver, gardens were virtually stripped and in various areas of the Valley potato tops were consumed and tubers damaged in the soil. Sugar beets grown for seed at Ladner and Westham Island, and rutabagas at Cloverdale, were severely damaged. In the dry southern interior of the Province, infestations of the red-backed and dark-sided cutworms were general. Damage in gardens varied from light to moderate. In field crops, spotty, severe damage affected hops at Kamloops; peas and barley at Armstrong; potato, melon, and beans at Vernon; tomato, cucumber, and sweet pepper at Westbank; and asparagus in all districts. The red-backed cutworm was injurious also in west-central British Columbia at Smithers, and from Fort St. John eastward into the Peace River district of Alberta, where rape and other crops were attacked. Light infestations of the variegated cutworm and the bertha armyworm occurred at Grand Forks and Soda Creek. Light damage was caused by the beet armyworm, *Laphygma exigua* (Hbn.), to the foliage and fruit of tomato at Lillooet and Pavilion; this was the first record of the insect in the Province and the first record of economic damage by this insect in Canada.

In Alberta, some increase occurred in numbers of larvae of the pale western cutworm, but damage was light and confined to extreme southern and northern areas of the Province. An increase in numbers in 1959 was expected. The red-backed cutworm was a serious pest in the parkland areas of central Alberta and in the Peace River block. In the High River and Blackie areas, damage was less severe than in 1957. Control measures were general in the affected areas. Damage by the army cutworm was very light.

In Saskatchewan the pale western cutworm was more numerous than in any other year since 1951, causing considerable damage in the Kindersley-Pinkham-Smiley-Coleville area and spotty damage at other points. The red-backed cutworm was more abundant and widespread in distribution than in the previous 30 years. In the agricultural area north of a line from Lloydminster through Unity, Biggar, Craik, and Yorkton, larvae were present in over half

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of the seeded fields. Crop destruction was complete in many fields, but the average loss in most areas was light. Coarse grains, flax, and rape were most severely damaged and hundreds of acres were sprayed. Damage in gardens ranged from moderate in most to severe in a few. The flax bollworm was more numerous and injurious than in any other year since 1946. In the Zealandia-Rosetown-Herschel area, every flax field examined in a survey was infested and damage averaged eight per cent. Elsewhere in west-central Saskatchewan, infestation was general and damage ranged from a trace to five per cent. Several other cutworm species, injurious in 1957, caused no economic damage.

In Manitoba, *Euxoa* spp., mainly the red-backed cutworm, were very numerous in the Morden-Altona area and throughout much of southwestern Manitoba. Damage in gardens was extensive. Sunflower, peas, beans, flax, and barley were attacked and 4,250 acres of sugar beets were sprayed. Economic damage by other species was not observed.

In southwestern Ontario, cutworms caused more damage than in 1957. The black cutworm, the principal species, was destructive for an unusually long period and required control measures on hundreds of acres of sugar beets. The armyworm and the variegated cutworm caused little damage. In eastern Ontario, cutworms caused about the usual amount of damage in gardens. The glassy cutworm damaged the roots of corn considerably at Ottawa; the armyworm, although found in 20 per cent of the fields of hay and grain examined in a survey of the Ottawa area, caused only light to moderate damage.

In the St. Anne de la Pocatiere area of Quebec, cutworms were present in moderate numbers and damage by the armyworm was not reported.

In New Brunswick, cutworm damage was generally moderate. The armyworm was commonly found in a survey of Charlotte, York, and Kings counties, but no serious damage was reported. In Sunbury County the fall armyworm caused some severe local damage to sweet corn.

In Nova Scotia the dark-sided cutworm was more numerous than in 1957 in gardens in Kings County, and small numbers of the armyworm were found here and in Cape Breton County. At Cow Bay the bronzed cutworm again appeared in a moderate outbreak. For the third successive year the fall armyworm was absent on corn.

In Prince Edward Island the variegated cutworm caused damage only in a few isolated areas and the armyworm and the red-backed cutworm were not reported.

In Newfoundland the bronzed cutworm appeared in unusually large numbers in fields near St. John's and the armyworm was conspicuous by its absence.

EUROPEAN EARWIG.—In British Columbia, populations of this earwig remained at a low level. In Nova Scotia the insect increased its distribution being recorded for the first time at Pictou. In Newfoundland, populations were larger than in 1957, notably because of a mild winter.

GRASSHOPPERS.—In the interior of British Columbia, grasshopper infestations varied greatly in intensity and in the species involved. In the Province as a whole, hatching was early and there was a definite increase in numbers. The following zones were sprayed in the acreages indicated: Nicola, 13,680; Clinton, 2,760; Princeton, 900; Thompson Valley, 700. A little spraying was done in the Riske Creek and Pavilion zones. Infestations in the East Kootenays were light to moderate and lighter than in 1957. Pasture and hay fields were severely damaged in the Celista, Tappen, and Westbank districts. In the Thompson Valley, *Melanoplus bilituratus* (Walk.) was the main species. *Amphitornus coloradus* (Thos.) was numerous in spear grass and *Camnula pellucida* (Scudd.) in blue grass. On Pavilion Mountain, *C. pellucida, Melanoplus bruneri* Scudd. and *M. borealis* (Fieber) were present in economic numbers. In the Cariboo and Chilcotin areas, infestations were scattered and light. In the Kersley district, *M. bivittatus* (Say) and *M. bruneri* increased slightly, especially where a two-year cycle had been indicated in previous years. In the Dragon Lake area, *M. borealis* occurred in light to moderate infestations. In the Taylor area, *M. bivittatus, M. bruneri,* and *M. borealis* occurred in that order of abundance; other species were scarce.

In Alberta, populations increased considerably in southern agricultural areas, but timely rains gave crops a good start and grasshopper damage was light, except in the Macleod area, where considerable spraying was done. In south-central agricultural areas, light to moderate infestations were noted. *M. bilituratus* and *C. pellucida* contributed to the increase in numbers in most areas. *M. bivittatus* increased little. Populations in 1959 were expected to be larger than in 1958.

In Saskatchewan the most severe infestations occurred in the south-central agricultural areas. However, outbreaks occurred eastward in the most southerly part of the Province, westward along the south bank of the South Saskatchewan River as far as Alberta, and northward to Mortlach. Lesser outbreaks extended northward to Saskatoon and Prince Albert. About 1,500,000 acres of land were treated with insecticides, the threat of damage being intensified by a prolonged spring drought. In relation to grasshopper abundance, however, crop losses in general were not serious, partly because of effectiveness of the control campaign; but forage losses were believed to have been extensive. Despite the vigorous control campaign, the average number of eggs were laid, adult surveys revealed a substantial increase compared with 1957, and the forecast for 1959 indicated a substantial increase in intensity and in area of infestation as compared with 1958. Economic infestations were forecast in about 970 townships, an increase

in area of 70 per cent. A few small areas, notably in the Mortlach and Coronach districts, were expected to have fewer grasshoppers than in 1958. The clear-winged, the migratory, the two-striped, and the Packard grasshoppers were the principal pest species involved in the outbreak.

In Manitoba, forecast infestations were equalled or exceeded in most areas. In the Red River Valley, however, about 40 per cent of the eggs of the two-striped grasshopper were desiccated. The most severe and extensive infestations occurred in the southwestern areas (Brandon, Souris, Oak Lake, Pipestone, Hartney, Melita, and Lyleton districts). Populations ranged from 25 to 100 per sq. yd. in many areas. Damage to pastures, hay, and grain was extensive. In the Carmen, Haywood, Neepawa, and Gladstone districts, infestation ranged from light to severe. Damage in these drought areas was excessive, control measures being negligible because of drought conditions. The major species were the same as those involved in Saskatchewan. The forecast for 1959 showed a slight decrease in the area of infestation, but in many infested areas populations were expected to be larger than in 1958, partly because control measures were not applied.

In Eastern Canada, grashhoppers, although fairly numerous in many agricultural areas, were of minor economic importance. Most inquiries regarding control were received from gardeners.

INSECTS FEEDING ON WEEDS.—Infestations of a chrysomelid. *Trirhabda pilosa* Blake, first observed in 1954 on sagebrush, *Artemisia tridentata* Nutt., persisted in a tract of rangeland south of the Thompson River, B.C., some six miles southwest of Kamloops. The number of defoliated bushes was noticeably greater than in 1956. In 1958, another infested area was observed about seven miles northwest of Kamloops, large numbers of sagebrush being severely defoliated.

JUNE BEETLES.—In British Columbia, white grubs damaged strawberry, potato, and other plants at Kamloops; strawberry at Vernon; and potato crops in the Okanagan Valley. In Saskatchewan, potatoes were damaged at Rose Valley and Melfort. In Manitoba, strawberry plants were attacked at Steinbach. In Ontario, Quebec, and New Brunswick, most white grubs, *Phyllophaga* spp., were in the third year of development and caused very little damage. In Nova Scotia, larvae were numerous in Yarmouth, Hants, and Annapolis counties. In Prince Edward Island they were numerous in some areas, but were not considered serious pests.

PAINTED-LADY.—In both the coastal and interior areas of British Columbia, unusually large numbers of larvae of the painted-lady caused conspicuous defoliation of Canada thistle, *Cirsium* sp., and at Lavington peas were slightly damaged. Large numbers occurred also in Alberta, feeding on thistle in northern areas and seriously attacking sunflower also in southern Alberta. In Ontario, unusual numbers fed mainly on thistle, but caused minor damage to soybean and corn. In New Brunswick, thistle was heavily infested in the St. John River Valley and larvae were heavily parasitized.

A SAP-FEEDING BETLE.—*Glischrochilus quadrisignatus* (Say) was numerous on several crops in southwestern Ontario, frequently causing damage to sweet corn, raspberries, and tomato.

SIX-SPOTTED LEAFHOPPER. — This vector of the virus of yellows and purple top, seriously affecting vegetables and other hosts in the Prairie Provinces and Ontario in 1957, caused considerably less damage in 1958.

A WEBWORM.—The webworm *Cnephasia virgaureana* Treit. caused extensive damage to red clover near St. John's, Nfld., and fed on strawberry, lupin, cabbage, honeysuckle, and viburnum.

WIREWORMS.—In British Columbia, *Agriotes sparsus* Lec. and *Ctenicera lobata caricina* (Germ.) continued to damage potatoes near Ladner. *Hypolithus impressicollis* (Mann.), first found in economic numbers near Ladner in 1957, occurred in heavy infestations in two potato fields in this area. At Agassiz, *Agriotes obscurus* (L.) increased its range slightly. At Kelowna, several species together destroyed about 80 per cent of a corn crop. No damage was recorded in the Peace River area.

In Alberta a survey of cereal crops in southern areas revealed average damage of only about two per cent. In sugar beets, too, damage was generally light. In the Turin area the sugar-beet wireworm was found in economic numbers for the second time on one farm and a few specimens were taken at two locations nearby.

In Saskatchewan, wireworms caused damage in 147 of 248 fields of cereal crops examined in a survey. Thinning averaged slightly over four per cent and was generally greater on summer-fallow crops than on stubble crops. Greatest damage occurred on wheat, followed by barley and oats. Excepting the northeastern agricultural area, damage was general throughout the Province and much more widely distributed than usual. In southwestern Saskatchewan, damage to cereals was unusually severe and widespread, several hundred acres being reseeded. Populations consisted mainly of *Hypolithus bicolor* Esch. and *Ctenicera aeripennis destructor* (Brown).

In Manitoba, *C. a. destructor* occurred in western agricultural areas in about normal abundance, some 8,000 to 10,000 acres of crops being treated with insecticide.

In most agricultural areas of Ontario, wireworm populations were held at a low level by the use of insecticides, and in Quebec damage was light.

In the Atlantic Provinces, too, damage was generally checked by control measures. In Nova Scotia, *Agriotes mancus* (Say) and *Hypolithus abbreviatus* (Say) were fairly numerous in Kings and Hants counties. No indications were found of spread of several recently recorded European species. *H. bicolor* (Esch.) was collected at Scott's Bay, Kings County. In Prince Edward Island, *Limonius pectoralis* Lec. became numerous in some potato fields in western areas, damage ranging from five to 75 per cent. In Newfoundland, *Agriotes lineatus* (L.) damaged turnips and cabbage at Foxtrap and Flatrock.

FIELD CROP INSECTS

APHIDS.—In the lower Fraser Valley, B.C., *Rhopalosiphum padi* (L.) occurred on wheat and rye in very large numbers in the spring. The English grain aphid appeared early on grain, but increased in numbers very slowly. Both species were well controlled by predators and parasites. In the Ladner-Westham Island area, the bean aphid and the green peach aphid damaged sugar beets.

In the Prairie Provinces the corn leaf aphid heavily infested some fields of barley in Alberta, but caused little damage, and the pea aphid was less abundant than in 1957 on alfalfa in this province. In Saskatchewan the English grain aphid was abundant on wheat and oats in a few localities in the north-central agricultural areas. The corn leaf aphid was abundant in a few fields of late barley at Aberdeen, Birch Hills, and Middle Lake. The turnip aphid was a minor, local pest on rape in northeastern agricultural areas. *Myzocallidium riehmi* Börner caused severe local damage to young sweet clover in experimental plots at Saskatoon and in east-central agricultural areas. No infestation was found in western areas. This was the first record of this aphid in the Province. In Manitoba, both the corn leaf aphid and the English grain aphid appeared on some cereal crops but caused little damage.

In Eastern Canada the corn leaf aphid severely damaged new tassels of corn in extreme southwestern Ontario, interfering with pollination. In southern Quebec this species infested many fields of oats and barley and some early corn, and in New Brunswick fairly heavy infestations developed on corn, grain, and the seed pods of shepherd's-purse, but in both provinces damage was slight. The English grain aphid heavily infested some cereal crops in southwestern Ontario and in York, Carleton, and Charlotte counties, N.B., and lightly infested grain locally in Prince Edward Island, but in all areas damage was light. In New Brunswick a fungus disease on oats was spread by the apple grain aphid in York and Sunbury counties.

BARLEY JOINTWORM.—In Prince Edward Island, the barley jointworm infested about 40 per cent of barley plants in the northeastern part of Prince County. In other infested areas of the Province infestation was light.

CLOVER-INFESTING WEEVILS.—In Alberta, when the alfalfa weevil was first recorded in 1957, counts averaged three larvae per net sweep in infested fields. In 1958 they averaged 60 per sweep and the northern limit of infestation had extended beyond the Bow River. In southwestern Saskatchewan the weevil was more abundant in irrigated alfalfa than in any other year since it was first reported in 1954. It was common on alfalfa in the Val Marie, Eastend, Consul, Vidora, Govenlock, and Maple Creek districts. However, populations in most areas were below economic levels. The sweetclover weevil caused severe damage to new plantings of sweet clover in the Lethbridge and Calgary, Alta., areas. In Saskatchewan, it was numerous, but caused little serious damage, and in Manitoba it severely defoliated both first- and second-year plantings. In Manitoba, *Sitona scissifrons* Say occurred in alfalfa in small numbers. At Ottawa, Ont., the clover head weevil was scarce and in southern Quebec the clover root borer and *Sitona* spp. occurred in small numbers.

CORN EARWORM.—In British Columbia, scattered infestations of the corn earworm occurred in the lower Fraser Valley and at Thrums and Nakusp in the Kootenay district. The insect was not reported in Alberta or Saskatchewan and occurred in very small numbers in southern Manitoba. In southwestern Ontario it lightly infested the fruit of tomato at Chatham and commonly infested corn in Essex and Kent counties. In southern Quebec, infestation was generally lighter than in 1957, but ranged up to six per cent in the St. Jean and St. Hyacinthe areas. In New Brunswick, damage was greater than in 1957, cob infestation being over 30 per cent in the Maugerville-Sheffield area. In Nova Scotia, populations were below average generally. In Prince Edward Island, damage was slight. In Newfoundland, sweet corn was extensively infested in the St. John's area.

DIAMONDBACK MOTH.—In southern Alberta this insect was so abundant that control measures were necessary in nearly all mustard fields. In Saskatchewan, severe infestations on rape in the Wilkie, Melfort, Humboldt, and Indian Head areas caused 50 per cent damage in some fields.

EUROPEAN CORN BORER. — A survey of corn in the area known to be infested in extreme southeastern Saskatchewan revealed infestation in only two of 26 plots and less than one per cent of the plants affected in these. In Manitoba the insect was very scarce except at the Canada Experimental Farm at Morden. In Ontario, infestation in Essex and Kent counties was very light. For the first time since 1946, when fall surveys were begun, infestation was more severe in the counties east and north of Chatham than in Essex and Kent. Average

infestation in five counties was 23 per cent. Sweet corn in Norfolk, Elgin, and Middlesex counties was severely infested in early plantings. Grain corn in hybrid test plots at St. Thomas, Verschoyle, Guelph, and Foxboro showed severe stalk breakage. At Ottawa damage was light, but at Stouffville it was severe.

In southern Quebec, damage to canning corn was lighter than in 1957 and developed later in the season. At the canning stage, an average of 10 per cent of the ears was infested. In New Brunswick, tassel infestation ranged from five to ten per cent and ear infestation was less than one per cent in Sunbury and York counties.

A LEAF ROLLER ON HOPS.—The oblique-banded leaf roller occurred in outbreak numbers on hops near Chilliwack, B.C., causing severe damage. It fed on the cones, webbed many together, and cut stalks, causing sound cones to drop.

LEGUME-POLLINATING BEES.—In alfalfa-seed crops in Manitoba, leaf-cutter bees were more numerous than in 1957 at Wanless. *Bombus terricola* Kby., on the other hand, experienced about a 75 per cent reduction in numbers.

PLANT BUGS.—In British Columbia, plant bugs, mainly *Liocoris unctuosus* Kelton and *L. borealis* Kelton, were present in economic numbers throughout the seed-growing districts of the Peace River area. One heavy infestation was reported from Bear Flat. In the Grandview district, a heavy infestation of *Liocoris* spp. caused severe local bud blasting and stunting in alfalfa. In Saskatchewan, *L. unctuosus, L. borealis, Plagiognathus medicagus* Arrand, and *Adelphocoris lineolatus* (Goeze) were again the most injurious pests of alfalfa grown for seed in northern agricultural areas of the Province. *Liocoris* spp. were present in economic numbers in every seed field examined, though in smaller numbers than in 1957. *P. medicagus* was present in scattered fields in about the same numbers as in 1957. *A. lineolatus*, first found in economic numbers in northeastern agricultural areas in 1952, was found in alfalfa fields within a few miles of the Saskatchewan-Alberta boundary in 1958. At Wanless, Man., over 90 per cent of the plant bugs found on alfalfa were of *Liocoris lineolaris* (Beauv.). *Adelphocoris rapidus* (Say) was present in small numbers. In Ontario, *L. lineolaris* was unusually abundant on alfalfa in the Chatham area. At Ottawa, *L. lineolaris, A. lineolatus*, and *Plagiognathus chrysanthemi* (Wolff) were present on clovers and alfalfa in average numbers. In southwestern Quebec the four-lined plant bug, more numerous than usual, damaged lettuce in the Chateauguay Valley.

SOD WEBWORMS.—In British Columbia, *Crambus* sp. continued to increase in the Victoria area and *C. vulgivagellus* Clem. was generally distributed in the Lower Fraser Valley. In Pictou County, N.S., injury to clover was rather less than in 1957.

SPITTLEBUGS.—In southwestern Ontario the meadow spittlebug was abundant on alfalfa and seriously inconvenienced growers of strawberries. At Ottawa, numbers on forage crops were much above normal, infestation averaging 32 per cent of the stems in alfalfa and 40 per cent of the stems in red clover and bird's-foot trefoil. Adults were unusually numerous in July, averaging 35 per net sweep. Infestation was general in the area. In southern Quebec, populations were large but damage was not severe.

SUGAR-BEET INSECTS. — In Alberta the sugar-beet root maggot, *Eurycephalomyia myopaeformis* (Roed.), increased in numbers. Damage to untreated beets in light soil areas ranged from 25 to 100 per cent. Control measures were applied on over 5,000 acres in the Taber area alone. Some larvae and adults were found in heavier-soil areas near Coaldale and Monarch. The sugar-beet root aphid was common but caused no severe damage. *Phyllotreta* sp. and *Silpha bituberosa* Lec. also caused little damage and the control acreage was considerably reduced from that of 1957. In Manitoba the sugar-beet root maggot continued to spread in the area west of Altona and Gretna. All beet fields in the light soil areas south of Winkler and Plum Coulee were infested, some severely.

SUNFLOWER INSECTS.—In the main sunflower-growing area of Manitoba, the sunflower maggot was present in 99 per cent of all plants examined. The banded sunflower moth was at its lowest level since 1949, damage averaging about one per cent. The sunflower moth was not noted. Infestation by the sunflower beetle was the heaviest yet seen in Manitoba, up to 300 larvae per plant being observed. Numerous migrants of the painted-lady were seen at Winnipeg in the spring, but little damage occurred on sunflower. A weevil, *Rhynchites aeneus* Boh., decapitated some plants, confining most of its activities to volunteer sunflowers. Grasshoppers were plentiful but did little damage to sunflowers. The six-spotted leafhopper was much less numerous than in 1957 and aster yellows virus infection was greatly reduced. Some armyworm damage was recorded for the first time.

THRIPS.—In British Columbia, *Haplothrips niger* (Osb.) caused concern to growers of red clover seed at Dawson Creek and Fort St. John, but no economic damage was observed. In northern Alberta, *Haplothrips leucanthemi* Sch. was abundant on clover and gladiolus. In northern agricultural areas of Saskatchewan, *H. niger* occurred in small numbers in all red and alsike clovers, but damage was minor. In Manitoba, *H. niger* was very numerous in the major areas producing red clover seed, and some thrips occurred on barley. At Ottawa, Ont., *Anaphothrips obscurus* (Müll.) was scarce in cereal grasses.

TOBACCO INSECTS—In southwestern Ontario an unprecedented outbreak of the seed-corn maggot damaged 15 to 20 per cent of tobacco transplants, but most recovered. Some loss from root rot occurred, probably associated with maggot damage. Aphids, virtually absent for

several years, appeared in large numbers and were considered responsible for a marked increase in virus diseases. The tomato hornworm was less numerous than in 1957 and the tobacco hornworm was a minor pest, as was also the cabbage looper. Earthworms and ants caused some damage in tobacco seed beds.

WHEAT MIDGE.—In the Kersley, B.C., area, spring wheat was severely attacked by the wheat midge. In test plots at Winnipeg, Man., infestation of nine varieties of wheat ranged from one to seven per cent. Only the variety Frontana was free of infestation.

WHEAT STEM MAGGOT.—Normal numbers of this insect occurred in Manitoba, the only province reporting the insect's presence.

WHEAT STEM SAWFLY.—In Alberta no increase in damage by this sawfly was noted. The area between Lethbridge and Chin Lake was the most severely infested. In Saskatchewan, severe sawfly damage occurred west of Estevan, east of Assiniboia, in the area around Gravelbourg, and between Portreeve and Abbey. Data on central Saskatchewan was incomplete. In Manitoba, infestation remained very light.

WOOLLYBEAR CATERPILLARS.—Unidentified species were numerous in the interior of British Columbia. At Bow Island, Alta., several thousand acres of pasture were severely damaged. In Saskatchewan, *Apantesis williamsi* Dodge lightly damaged pasture at Golden Prairie.

VEGETABLE INSECTS

ALFALFA LOOPER. — For the third successive year, this insect damaged lettuce at Cloverdale, B.C.

APHIDS.—In British Columbia, as a result of very mild weather, some species of aphids reproduced outdoors during the winter and populations built up rapidly to high levels in the spring. The pea aphid was more numerous than usual on peas in the lower Fraser Valley. The cabbage aphid caused severe damage to cruciferous vegetables in southern Vancouver Island and the lower Fraser Valley and spotty damage in the Okanagan Valley. In the lower Fraser Valley, the green peach aphid developed in large numbers on potatoes and persisted through the season, spreading leafroll virus to an unusual extent. Other aphid species on potatoes were generally scarce throughout the Province. In Alberta and Saskatchewan, aphids and their predators were generally scarce. In Manitoba the green peach aphid was more abundant than usual on potatoes at Winnipeg, but other potato aphids were generally scarce. The pea aphid caused extensive damage to alfalfa, field peas, and sweet clover in southern Manitoba, especially in the Winnipeg area and the south half of the Red River Valley. In Ontario the pea aphid occurred in light to moderate infestations on some 2000 acres of canning peas and was numerous on alfalfa in southwestern counties. In the Ottawa area, numbers on red clover, alfalfa, and bird's-foot trefoil were much above normal. Infestations of the cabbage aphid on cruciferous vegetables were moderate in southwestern Ontario, severe in some areas of central Ontario, and unusually light in eastern Ontario. For the first time in nine years, the bean aphid attained economic importance in southwestern Ontario, severely infesting field and lima beans. Minor infestations in the area included the potato aphid on peppers, the melon aphid on cucumber, and the turnip aphid on radish and turnip. In southwestern Quebec the pea aphid was a major pest on canning peas and the potato aphid and buckthorn aphid developed in abnormal numbers on potatoes. In New Brunswick, potato aphids developed in about normal numbers and parasites and predators were unusually abundant. The pea aphid occurred in small numbers on canning peas. In Nova Scotia, aphids in general appeared early and were more numerous than usual. Potatoes were severely injured in Kings, Antigonish, and Cumberland counties. The pea aphid required control measures in the Annapolis Valley, and aphids were generally abundant on barley, oats, and corn. In Prince Edward Island, aphids, with a few exceptions, were not numerous on potatoes and the potato aphid made up over 95 per cent of the population.

ASPARAGUS BEETLES.—At Winnipeg, Man., the spotted asparagus beetle was abundant but caused little damage. In southwestern Ontario, too, it was a minor pest and the asparagus beetle was unusually scarce, probably because of cool weather.

CABBAGE SEEDPOD WEEVIL.—In the lower Fraser Valley, B.C., control measures were necessary for this pest on cruciferous seed crops.

CATERPILLARS ON CRUCIFERS. — In the lower Fraser Valley, B.C., the imported cabbageworm appeared a month earlier than usual and developed in normal numbers. The diamondback moth was more abundant than usual and the cabbage looper was generally scarce. In the interior of the Province, the imported cabbageworm was widely injurious and in the Kamloops and North Okanagan areas, more so than in 1957. In southern Alberta and Saskatchewan, the diamondback moth was extremely abundant on many hosts. In the latter Province the imported cabbageworm caused less damage than in any other year since 1953. In Manitoba, caterpillars were generally scarce on crucifers. In southwestern Ontario, populations of the imported cabbageworm were normal, damage by the diamondback moth was light, and the cabbage looper was less numerous than in 1957. In eastern Ontario, at Ottawa, the imported cabbageworm was less numerous than in any other year since 1950. Populations of

the diamondback moth were the largest in ten years on early crucifers, but were below average on late crucifers, mainly a result of heavy rains and parasitism. The cabbage looper was less numerous than usual. In southern Quebec and New Brunswick, the imported cabbageworm occurred in subnormal numbers and the cabbage looper was scarce. On Cape Breton Island, N.S., the imported cabbageworm was numerous; on Prince Edward Island it was scarce; and in Newfoundland it was numerous in all areas. The diamondback moth was numerous in the Annapolis Valley, N.S., scarce in Prince Edward Island, and abundant on turnips about Heatherton, Nfld. The zebra caterpillar was numerous on Cape Breton Island, N.S., and the purple-backed cabbageworm was abundant on cabbage and turnip in Newfoundland.

CARROT RUST FLY.—In coastal areas of British Columbia, the carrot rust fly was well controlled. In the North Okanagan area, damage occurred on parsnip and carrot. In Ontario and Quebec, second-generation maggots, where not controlled, caused severe damage to late carrots. In New Brunswick, populations were larger than in 1957 and most susceptible crops were damaged, some severely. Damage in Nova Scotia was spotty and in Prince Edward Island and Newfoundland fairly light.

CARROT WEEVIL.—In the Holland Marsh, Ont., damage to early carrots was less than in 1957. Some damage was reported also from Brockville.

COLORADO POTATO BEETLE.—In British Columbia, infestation was more severe than in 1957 in the Kootenay and Slocan valleys. At Grand Forks, infestation was moderate and about 150 acres were treated by aircraft. In the Prairie Provinces, infestation was generally lighter than in 1957. In some untreated potato fields in southwestern Ontario, about six per cent of the plants were severely defoliated and 25 per cent lightly defoliated. In eastern Ontario and southern Quebec, the insect was abundant and injurious. In the Atlantic Provinces it was fairly well controlled except in some home gardens.

CUCUMBER BEETLES.—In southwestern Ontario the striped cucumber beetle was numerous, but it was well controlled in commercial plantings. In southern Quebec and New Brunswick, it was scarce and in Prince Edward Island apparently absent. The spotted cucumber beetle was of minor importance in Ontario, but fairly abundant in southern Quebec, especially in the Richelieu Valley.

FLEA BEETLES.—In British Columbia the tuber flea beetle occurred in an unprecedented outbreak in southern Vancouver Island, favourable weather and too early suspension of control being mainly responsible. At least 100 acres of potatoes were unmarketable. In the lower Fraser Valley, damage occurred wherever control was neglected. In the southern interior of the Province, damage was the most severe in several years. In southwestern Ontario the potato flea beetle was not as abundant as in 1957, but damage to potato and radish was common. In the Ottawa River Valley, damage was greater than usual. In the remainder of Eastern Canada, development started slowly, but the insect increased to normal numbers in most areas. In Saskatchewan, *Phyllotreta* spp. were less numerous than in 1957 and damage was light, but in Manitoba heavy infestations developed on radish, cabbage, cauliflower, and potatoes. In Ontario, *Phyllotreta cruciferae* (Goeze), recently introduced into eastern Canada, caused widespread damage to rutabagas and seed crucifers in the central area of the Ottawa River Valley for the fourth successive year.

TOMATO HORNWORM.—Populations of the tomato hornworm were small in Ontario.

LEAFHOPPERS.—Populations of the six-spotted leafhopper were small in the Prairie Provinces. In contrast with 1957, very little aster yellows was reported and damage to susceptible crops was negligible. In Ontario, populations were again large, but not in such outbreak proportions as in 1957, and yellows, although widespread, was less in evidence, especially in market gardens. Infection of celery was light in most plantings, but damage to carrots and lettuce was again severe, even in some treated plantings, in both southwestern and eastern Ontario. Minor infection was noted in onions and tomatoes. In southern Quebec the insect was reported to be abundant and in Prince Edward Island populations on potatoes were slightly larger than usual. Large numbers of the potato leafhopper appeared, as usual, in southwestern Ontario, causing severe damage to potatoes and light to moderate damage to beans and alfalfa. In eastern Ontario and southern Quebec, populations were relatively small.

ONION MAGGOT.—In the southern interior of British Columbia, damage by the onion maggot was the most severe since 1950, even in treated plantings. In the Prairie Provinces, normal populations caused some severe damage, notably at Winnipeg, Man. In western Ontario the most severe outbreak on record developed and persisted to the end of the season. All onion varieties were infested, losses ranging to 100 per cent in many plantings. In this area, as in British Columbia, strains highly resistant to insecticides had developed. Losses were particularly heavy in the Thedford-Grand Bend and Holland-Bradford marshes. Infestation occurred even in mature and harvested onions. In southern Quebec, development was delayed by unfavourable weather and infestation remained relatively light. Approximately 35 per cent of first-generation pupae examined were parasitized. In New Brunswick, most damage occurred in small gardens.

MEXICAN BEAN BEETLE.—This insect continued to be a pest of beans, especially red kidney beans, in Lambton County, Ont., but showed little indication of spreading.

PEA LEAF WEEVIL.—This weevil again severely damaged seedling peas at Sumas Prairie and Chilliwack, B.C.

PEA MOTH.—In the lower Fraser Valley, B.C., the pea moth seldom attains damaging numbers, as most peas are harvested green when the larvae are immature. In New Brunswick, small acreages experienced 50 to 70 per cent infestation, but canning peas were not damaged. In Prince Edward Island, damage was greater than usual.

PLANT BUGS. — In carrot seed crops at Grand Forks, B.C., infestations of *Orthops scutellatus* Uhl. ranged from light to severe, but other related species were scarce. In southern Quebec the tarnished plant bug severely damaged potatoes and other hosts. In Nova Scotia it was normally abundant, causing some severe damage, and in Prince Edward Island it was generally distributed in light to moderate infestations.

RED TURNIP BEELE.—In British Columbia the red turnip beetle caused considerable damage to garden crucifers at Dawson Creek and Fort St. John. In northern Alberta it occurred in gardens and in northeastern Saskatchewan it fed lightly on rape.

ROOT MAGGOTS IN CRUCIFERS.—In the lower Fraser Valley, B.C., the cabbage maggot caused damage wherever control measures were inadequate. The insect was identified for the first time in Manitoba from larvae taken on rape at Winnipeg. In Ontario, spring damage to cruciferous transplants and to early turnips and radish was extensive, some early turnips being ploughed under. In the Ottawa area, damage was well above normal, but not as severe as in 1957. In southern Quebec, damage was extensive and similar to that found in Ontario. At Maugerville and Sheffield, N.B., untreated early cabbage and cauliflower were a total loss and even treated plants were considerably damaged. Losses in turnips grown for market and seed were extensive in several counties. In Nova Scotia the insect was normally abundant, but control measures effectively protected most turnips. In Prince Edward Island and Newfoundland, damage was generally severe, more so than in 1957 in the latter Province. In Saskatchewan, *Hylemya planipalpus* (Stein) was less injurious to radish than usual and at Brandon, Man., it was more injurious than in 1957. *Hylemya floralis* (Fall.) occurred in normal numbers in British Columbia and Saskatchewan. In Manitoba, losses in turnips were severe at Winnipeg and Brandon, and in New Brunswick infestation was generally heavy.

SEED-CORN MAGGOT.—In Saskatchewan the seed-corn maggot was not reported for the second successive year. In Ontario, infestations were well controlled in southwestern areas, but at Ottawa beans were severely damaged. For the first time in several years, no infestation was observed at St. Anne de la Pocatiere, Que. In Carleton County, N.B., seed potatoes were heavily infested. In Nova Scotia, infestation was below average but heavier than in 1957. In Prince Edward Island, too, numbers were below average, but some severe damage occurred on beans and cucumbers.

SLUGS. — In British Columbia, slugs infested gardens generally and were unusually numerous in the north Okanagan Valley. In Saskatchewan, damage to garden crops was reported from Saskatoon and Eatonia. In the Winnipeg, Man., area, infestation was severe. In southwestern Ontario, damage was the lightest in several years, but in the Ottawa Valley it was greater than usual. In southern Quebec, too, damage was above average. In the Atlantic Provinces, damage was general in gardens, being especially severe in Newfoundland.

SQUASH BUG.—In southwestern Ontario, infestation of squash and pumpkin was considerably less severe than in the previous five years. In eastern Ontario it was light in the Frankford-Cannington area.

SPINACH LEAF MINER.—In British Columbia the spinach leaf miner lighly damaged spinach at Lavington and Vernon. In Alberta it caused more severe damage than for several years in sugar beets but losses were minor. It was not reported in Manitoba, but in southwestern Ontario it caused slight damage to beets and spinach.

STEM BORERS.—In southeastern Quebec the potato stem borer appeared to be increasing in numbers, attacking corn, rhubarb, and potatoes. In New Brunswick, rhubarb was ruined at Maugerville and potatoes damaged at Hartland, Woodstock, and Centreville. In the counties of Kings, Pictou, and Inverness, N.S., potatoes, tomatoes, and rhubarb were severely infested. In Newfoundland, infestation was generally light excepting a local outbreak on potatoes at St. John's. In Ontario the burdock borer damaged tomatoes in several gardens at Ottawa.

THRIPS.—Infestation of onions by the onion thrips was generally light in southwestern Ontario.

A TORTRICID.—In Prince Edward Island, *Cnephasia virgaureana* Treit. attacked almost all vegetable crops as well as clover and strawberry, causing considerable damage.

FRUIT INSECTS

APHIDS.—In the interior of British Columbia, *Aphis pomi* DeG. was less numerous on mature apple trees than in 1957, but it was abundant on young trees. In Ontario it was very abundant in Essex and Kent counties, moderate in Norfolk County, and, in general, not a serious problem on apple in other areas of the Province. In Quebec it was very scarce at Ste. Anne de la Pocatiere, but required control measures in some other areas. In New Brunswick and Nova Scotia it was generally present but caused little damage. In Newfoundland, considerable infestation was reported. In the interior of British Columbia, *Sappaphis plantaginea* Pass (prev. *Anuraphis roseus* Baker), was of no economic importance. In Ontario it was scarce except in Norfolk County. In southwestern Quebec early outbreaks occurred in a few orchards at

Rougemont. In both New Brunswick and Nova Scotia, injury was light, although somewhat increased in the former Province. In coastal areas of British Columbia, *Myzus ascalonicus* Doncaster caused considerable damage to strawberry plantings. In the interior the thistle aphid and the mealy plum aphid occurred commonly on unsprayed prune trees; the black cherry aphid and green peach aphid were of minor importance. In Manitoba the currant aphid infested red and white currants generally. In Ontario the black cherry aphid was more abundant than usual in Essex and Kent Counties, but in the Niagara Peninsula it was much less numerous than in 1957. Infestations of the apple grain aphid were heavier and more persistent than in 1957. In New Brunswick the woolly apple aphid was fairly common in the Gagetown area and populations of *Pentatrichopus* (prev. *Capitophorus) minor* (Forbes), *Pentatrichopus* (prev. *Capitophorus) fragaefolii* (Ckll.), and *Myzus porosus* Sand. showed little change. In Nova Scotia the woolly apple aphid increased materially in numbers only where its parasites were destroyed by insecticides. The apple grain aphid occurred in normal numbers and *Pentatrichopus* spp. were very numerous on black currant and moderately abundant in strawberry plantings.

APPLE (AND BLUEBERRY) MAGGOT.—In Manitoba the apple maggot, as usual, lightly infested hawthorn. In Ontario, infestation was generally light in commercial apple orchards, but prune was commonly infested in the Niagara Peninsula. In Quebec several orchards were lightly infested in the Montmagny area and a few were severely infested in the Rougemont area. In New Brunswick the insect was more numerous in commercial orchards than ever before recorded. Most were infested, a few severely, and in some cases startling increases occurred in heavily sprayed orchards. In Nova Scotia and Prince Edward Island, too, general increases in the number and severity of infestations were recorded, despite control measures. In New Brunswick, infestations on blueberry increased markedly, but in Nova Scotia infestation was generally light.

APPLE MEALYBUG.—In New Brunswick the apple mealybug was becoming increasingly important as a pest in apple orchards. In Nova Scotia, populations continued to be small.

APPLE SEED CHALCID. — In Manitoba, winter mortality was high and few adults developed. In New Brunswick and Nova Scotia, neglected trees were heavily infested, but the insect was generally of minor importance.

APPLE SUCKER.—In Nova Scotia the apple sucker declined markedly in numbers and the parasitic fungus *Entomophthora sphaerosperma* Fres. was very active in some orchards.

CANKERWORMS.—In Manitoba the fall cankerworm was not reported. At Rougemont, Que., following virtual absence for several years, it caused moderate damage. In Nova Scotia, control measures were required in Kings and Hants counties for infestations of the fall cankerworm and the winter moth, the latter species causing severe defoliation in neglected orchards. There was little change in the status of these species in the Annapolis Valley.

CASEBEARERS.—Casebearers were common in many orchards in Nova Scotia, *Coleophora anatipennella* (Hbn.) showing some increase.

CHERRY FRUIT FLIES.—In British Columbia, *Rhagoletis cingulata* (Loew) continued to be a major pest on unsprayed sweet and sour cherries on southern Vancouver Island. Adults of *Rhagoletis fausta* (O.S.) appeared too late to be of economic importance.

CICADAS.—In British Columbia, cicadas caused some damage to apple in the Okanagan and Kootenay districts.

CODLING MOTH.—In British Columbia, generally, the codling moth was more numerous than usual. In the interior it caused the greatest loss of fruit since the introduction of DDT. A long, hot season plus DDT tolerance were believed responsible. In Ontario and Quebec, the insect was generally less abundant than for several years, mainly because of low spring temperatures. Some local DDT tolerance in the Niagara Peninsula was suspected. In New Brunswick, injury was greater than in 1957. Little change occurred in Nova Scotia, the population in the Annapolis Valley being at about the lowest ebb in 20 years. In most orchards in Prince Edward Island it was almost impossible to find codling-moth damage.

CRANBERRY FRUITWORM.—In Nova Scotia, percentage injury to cranberry fruit was high, probably because of a very small crop. In Prince Edward Island, only a small percentage of fruit was infested.

CURCULIONIDS.—At Morden, Man., the plum curculio infested plum, apricot, and sour cherry. In Ontario the insect was generally much less injurious than usual, but appreciable, local damage occurred in the Georgian Bay and Oakville areas. In Quebec, damage was spotty and in Nova Scotia rather greater than in recent years. Damage to strawberry by *Brachyrhinus ovatus* (L.) was about normal in British Columbia and very light in the Prairie Provinces, none being reported in Manitoba. From Ontario eastward, infestation was generally below average and damage was light. No infestations of *Anthonomus signatus* Say were reported in Manitoba. From Ontario eastward to New Brunswick, infestation was light to average except in the areas of Grand Lake and Washademoak, N.B., where the species continued to be numerous. In Nova Scotia and Prince Edward Island, populations on strawberry continued to be large and injurious, although generally well controlled in commercial plantings. In British Columbia, *Sciopithes obscurus* Horn and *Nemocestes* sp. caused damage in a greater number of strawberry plantings than in 1957. *Brachyrhinus singularis* (L.) was reported for

the first time in the Yarrow district of the lower Fraser Valley, causing damage to a commercial raspberry planting, and in coastal areas the black vine weevil extensively damaged the crowns of loganberry.

CURRANT BORER.—A severe outbreak of this pest occurred on currant breeding stock in a greenhouse at Morden, Man.

CURRANT FRUIT FLY.—This species was reported from Alberta and from Lucky Lake and Beechy, Sask., and was a common pest of currant and gooseberry in Manitoba.

EYE-SPOTTED BUD MOTH.—This bud moth was less injurious than in 1957 in the interior of British Columbia. In Ontario it was generally not a serious pest. In southwestern Quebec, populations were slightly larger than in 1957. In the Atlantic Provinces the status of the pest remained exceptionally low, although a slight upward trend was indicated in Nova Scotia.

FRUIT TREE BORERS.—In the interior of British Columbia the peach twig borer caused little loss. In Ontario the peach tree borer and the lesser peach tree borer continued to cause moderate to severe injury where inadequately controlled. In Eastern Canada, generally, the roundheaded apple tree borer was of little importance.

GRAPE BERRY MOTH.—Damage in the Niagara Peninsula, Ont., was very light for the third successive year.

GRAPE PHYLLOXERA.—A survey in the Niagara Peninsula, Ont., indicated that this pest occurred on the roots of most grapes and on the leaves of a few varieties.

GREEN FRUITWORMS.—In British Columbia the cherry fruitworm was very scarce. In Manitoba a light infestation of the lesser appleworm occurred on apple at Morden, and in Nova Scotia *Lithophane* spp. and *Xylena* spp. caused little damage.

IMPORTED CURRANTWORM.—This pest was reported only in Eastern Canada, where it was generally not a serious pest, but caused considerable local defoliation of currant and gooseberry where not controlled.

LEAFHOPPERS.—On Vancouver Island, B.C., the bramble leafhopper and the rose leafhopper continued to cause extensive feeding damage on cane fruits. On Lulu Island these species caused considerable damage to loganberry, and *Macropsis fuscula* (Zett.) increased considerably, indicating rapid re-establishment after almost complete elimination by frost in 1955. In the interior of the Province, leafhoppers were numerous on apple and prune. In Manitoba a heavy infestation of the white apple leafhopper occurred on apple at Morden and the potato leafhopper caused some damage to nursery stock. In Quebec the apple leafhopper caused minor damage. In New Brunswick, at least two species of leafhopper attacked apple in the Gagetown area. In Nova Scotia the white apple leafhopper, the only species present in apple orchards, was moderately abundant. Virus infection of strawberry, caused by the six-spotted leafhopper, was much less conspicuous than in 1957.

LEAF MINERS.—In New Brunswick *Lithocolletis malimalifoliella* Braun was found only in a few orchards and infestations were much smaller than in 1957. In Nova Scotia it was more numerous than usual, occurring in many orchards.

LEAF ROLLERS.—In the interior of British Columbia, the fruit tree leaf roller continued to be a serious pest and *Exartema olivaceanum* (Fern.) lightly infested strawberries at Salmon Arm. In the Niagara Peninsula, Ont., the strawberry leaf roller was at its lowest ebb in several years. In the eastern half of the Peninsula, a comparatively new pest, *Swammerdamia caesiella* Hbn., occurred in many Japanese plum orchards. Throughout Ontario, populations of the red-banded leaf roller were the smallest in several years, although increasing in the St. Lawrence Valley, and the insect was scarce in Quebec. Also, on apple in Quebec, the fruit tree leaf roller caused minor damage, and *Pseudexentera mali* Free. appeared in small numbers at Rougemont and Abbotsford. In Nova Scotia the gray-banded leaf roller was the only leaf roller causing more than slight injury and it was the scarcest in several years. An unidentified leaf roller occurred in several blueberry fields.

MITES.—In the interior of British Columbia, *Tetranychus mcdanieli* (McG.) was the most injurious orchard mite of the season. The two-spotted spider mite was more injurious than in 1957 on many hosts both here and in the lower Fraser Valley. In coastal areas the redberry mite was unusually numerous on wild and cultivated blackberry. In the interior the European red mite and *Eriophyes* spp. were generally well controlled. The cyclamen mite again infested strawberry in the Creston area. The yellow spider mite caused little economic damage and *Bryobia arborea* M. & A. was not important. In Saskatchewan, mites caused some damage to strawberry at Moose Jaw and to raspberry at Kindersley, and *Eriophyes amelanchier* Stebb. occurred on Saskatoon berry at Swift Current. In Manitoba a general infestation of *T. mcdanieli* seriously damaged raspberry, but no other species was recorded as injurious. In most fruit-growing areas of Ontario, the European red mite was not a serious pest, but in the Niagara Peninsula and in Essex County, heavy infestations developed on apple, peach, plum, and some pear, indicating widespread insecticide resistance. The two-spotted spider mite was generally scarce in southwestern Ontario, but in eastern areas a considerable number of apple orchards were heavily infested. In southwestern Quebec the European red mite was generally in light infestation until early August, at which time populations increased in some orchards. In New Brunswick the European red mite was a problem in only a few orchards and the

two-spotted spider mite was common in the Grand Lake and Washademoak areas. In Nova Scotia the European red mite caused little damage, except in orchards treated with DDT in recent years. The clover mite caused the least damage in several years. The pear leaf blister mite, usually injurious mainly to young pear trees, caused considerable damage to bearing trees. The cyclamen mite severely injured several varieties of strawberry and the two-spotted spider mite remained a minor pest. In Prince Edward Island the European red mite was more abundant than usual and in this Province and Newfoundland the pear leaf blister mite was a serious pest, practically all pear trees being infested.

OMNIVOROUS LEAF TIER.—This pest, first recorded in British Columbia in 1957, occurred in increased numbers in most large strawberry plantings in coastal areas and was taken also on thistle, vetch, and clover.

ORIENTAL FRUIT MOTH.—Extensive trapping for this pest in the Okanagan Valley, B.C., failed to reveal any moths. In Ontario, infestation was comparatively light in the Niagara Peninsula excepting a serious local outbreak at St. Davids. A considerable increase in numbers occurred in Essex County and slight increases in Kent and Lambton counties.

PEAR PSYLLA.—In the interior of British Columbia, in contrast to 1957, the pear psylla was a major pest difficult to control. In the Niagara Peninsula, Ont., it was more numerous than for several years. However, except in eastern Ontario, later generations were small. In Nova Scotia the insect was less numerous than usual.

PEAR-SLUGS. — In coastal areas of British Columbia the pear-slug occurred in heavy infestations on pear and cherry, but in the interior it remained at a low ebb in most orchards. In Eastern Canada, infestations were generally minor and local with a few exceptions. In British Columbia, *Pristiphora californica* (Marl.) was of little importance.

PLANT BUGS.—The tarnished plant bug and other species continued to be minor pests in all fruit-growing areas of Canada. In Nova Scotia, *Criocoris saliens* (Reut.), *Campylomma verbasci* (Meyer), and *Lygus communis novascotiensis* Kngt. caused little damage in orchards, and *Calocoris norvegicus* (Gmel.) was well controlled on strawberry.

RASPBERRY BUD MOTH.—In the area about Belleisle, N.B., this pest was again fairly common.

RASPBERRY CANE BORERS.—*Oberea* spp. were in the adult stage in most of Eastern Canada, but damage was generally light to average. In eastern Ontario the flight was late and smaller than usual.

RASPERRY CANE MAGGOT.—This pest was present on loganberry and raspberry in British Columbia, but damage was generally light.

RASPBERRY FRUITWORMS.—In the Prairie Provinces, *Byturus* sp. was reported only from Bengough, Sask.

RASPBERRY ROOT BORER.—In British Columbia this insect continued to be a serious pest on Vancouver Island, in the lower Fraser Valley, and at Cranbrook and Vernon in the interior.

RASPBERRY SAWFLY.—This insect, rarely of economic importance, was seldom reported.

ROSE CHAFER.—In Essex County, Ont., the rose chafer was more injurious than usual in peach orchards and raspberry plantings.

SCALE INSECTS.—Increased numbers of the oystershell scale were recorded on unsprayed fruit and shade trees in the interior of British Columbia and on apple in southwestern Quebec. In other fruit-growing areas, populations were generally small. In the interior of British Columbia the European fruit scale was unimportant and the San Jose scale was effectively controlled where established. In the Niagara Peninsula, Ont., *Lecanium coryli* (L.) and *L. cerasifex* Fitch were widely distributed and almost all Japanese plum orchards were infested in varying degree. European plums were less affected, few heavy infestations being reported. Several heavy infestations occurred on peach and a few on grape. The new hybrid grape varieties were more susceptible than standard varieties. In 1957 and 1958 scales were particularly abundant on walnut, hickory, and filbert nut trees. *Pulvinaria* sp. was more abundant than in 1957, causing some severe smutting of fruit in this area, but in Essex County it was scarce. In Nova Scotia a few orchards were severely infested by *L. cerasifex,* but parasitism by *Blastothrix sericea* (Dalm.) was heavy.

STINK BUGS.—In the interior of British Columbia, stink bugs were more numerous than in 1957.

A STRAWBERRY CHLAMISUS.—*Chlamisus fragariae* Brown was not found on strawberry in New Brunswick in 1958.

TENT CATERPILLARS.—In the areas about Beaverbrook and Saskatoon, Sask., infestations of *Malacosoma* spp. were the heaviest ever observed. In New Brunswick they were unimportant, but the ugly-nest caterpillar severely defoliated wild apple and cherry. In Nova Scotia the eastern tent caterpillar was common, but less so than in 1956 and 1957, and in Prince Edward Island it was generally not a serious pest.

THRIPS.—In the interior of British Columbia, *Frankliniella occidentalis* (Perg.) caused little "pansy spot" on apple. In New Brunswick, *F. vaccinii* Morgan had virtually disappeared in Charlotte County, but in Nova Scotia it was present in varying abundance in all blueberry plantings, causing a complete loss in some.

WHITE-MARKED TUSSOCK MOTH.—Populations of this pest were at a very low level in New Brunswick and Nova Scotia.

YELLOW-NECKED CATERPILLAR.—This pest caused some economic damage in the south Okanagan Valley, B.C.

PREDATORS OF ORCHARD PESTS.—Most of the predators of apple pests were present in about average numbers. *Anthocoris musculus* (Say), which became unusually numerous in 1957, was nearly as numerous in 1958 and was an effective predator of several pests, including mites, aphids, and the apple sucker. Some species of mirids were more numerous than in 1957, whereas other species were scarcer, but in general they were present in about average numbers. *Haplothrips faurei* Hood, scarce in 1957, was more abundant in 1958. Typhlodromids increased in numbers in many orchards, but *Anystis agilis* Banks declined slightly. Pentatomids, coccinellids, and chrysopids seemed to be somewhat scarcer than in 1957, but they were probably present in about average numbers.

INSECTS AFFECTING GREENHOUSE AND ORNAMENTAL PLANTS

ALFALFA LOOPER.—Larvae of this looper severely damaged chryanthemums in greenhouses in the Victoria, B.C., area.

APHIDS.—In the lower Fraser Valley, B.C., the spruce aphid seriously damaged ornamental and Sitka spruce, destroying all of the older needles on many trees. The rose aphid reproduced outdoors all winter in this area and increased to major numbers during early summer. The potato aphid, *Macrosiphum euphorbiae* (Thomas), was common on tulips and together with *Aulacorthum solani* (Kltb.) damaged young holly plants. In Saskatchewan, aphid populations were small, but in Manitoba, aphids were unusually abundant on most hosts. In southwestern Ontario, numbers were above average. In southern Quebec the eastern spruce gall aphid was numerous on ornamental spruce, and in Newfoundland *Eriosoma ulmi* L. severely attacked elm.

BORING INSECTS.—In Manitoba the lilac borer and the columbine borer were reported. In southwestern Ontario, damage by the poplar and willow borer was below average and the locust borer was fairly common. In Prince Edward Island the lilac borer was less injurious than usual.

CURCULIONIDS.—In Saskatchewan, for the first time in 12 years or more, the rose curculio was not reported. In Manitoba it occurred in average numbers.

LEAFHOPPERS.—In the lower Fraser Valley, B.C., the rose leafhopper was numerous on many rosaceous hosts. In the interior the Virginia-creeper leafhopper was injurious and it was reported also in Alberta and from Saskatoon, Sask. At Morden, Man., a leafhopper heavily infested chinese elm.

LEAF MINERS.—The lilac leaf miner was commonly reported from Alberta eastward, infestation of lilac being generally severe in Newfoundland. In southwestern Ontario the birch leaf miner disfigured many ornamental birch.

MITES.—In British Columbia the bulb scale mite continued to increase in importance as a pest of narcissus grown in greenhouses. In Saskatchewan, mites damaged begonias at Rocanville and sweet peas at Saskatoon. In Manitoba, *Tetranychus mcdanieli* (McG.) was a major pest on many ornamentals, and in Ontario and Quebec the two-spotted spider mite was numerous on flowers, shrubs, and ornamental evergreens.

OAK LACE BUG.—This insect severely damaged oak in the Winnipeg, Man., area.

PEAR-SLUG.—The pear-slug was reported damaging cotoneaster, cherry, and plum in Alberta and Manitoba; ornamental cherry at Ottawa, Ont.; cotoneaster and other ornamentals in New Brunswick; and mountain ash in Newfoundland.

PINE SHOOT MOTHS.—In southwestern Ontario the European pine shoot moth caused rather less damage than usual to ornamental pine. In Prince Edward Island a large percentage of ornamental pine was extensively damaged by *Eucosma gloriola* (Heinr.).

SATIN MOTH.—In the Kamloops, B.C., area, infestations of this pest on poplar were the most severe since 1954. Poplar and willow were damaged also in the Okanagan Valley. In southern Quebec and Newfoundland, infestation was negligible.

SCALE INSECTS.—In the interior of British Columbia and in Manitoba, infestation of ornamentals by the oystershell scale was reported. The pine needle scale was reported from Alberta and from Richelieu, Que. The cottony maple scale severely infested Manitoba maple in Alberta and the Winnipeg, Man., area, and soft maple at Erie Beach, Ont. In the Lethbridge, Alta., area caragana was attacked by *Lecanium cerasifex* Fitch.

THRIPS.—Infestation of untreated gladiolus by the gladiolus thrips was not uncommon, but no other species were reported.

INSECTS ATTACKING MAMMALS AND BIRDS

BAT BUGS. — Records of bat bugs included Oxlow, Sask., probably involving *Cimex pilosellus* (Horv.), and Hamilton, Ont., where *Cimex adjunctus* Barber was probably the species present.

BED BUG.—Infestations of the bed bug were reported from Merritt, B.C.; Lethbridge and Edmonton, Alta.; Saskatoon, Sask.; Winnipeg and Brandon, Man.; and Ottawa, Windsor, Port Dover, Midland, and Harlowe, Ont. Inquiries generally were not numerous.

BLACK FLIES.—On the Empire Valley Ranch in the southern Chilcotin, B.C., the reduction of warbles, lice, and hornflies by the application of Trolene revealed that black flies, unaffected by systemics, were important pests in this area. In Saskatchewan, outbreaks were minor as in 1957, but some annoyance was caused to livestock at Parkside, Saskatoon, Shellbrook, and Abbey. At Uranium City, humans were attacked. *Simulium bivittatum* Mall. was recorded for the first time in the Province at Saskatoon, where it annoyed horses. In Manitoba, black-fly populations were small, but in Newfoundland they were larger than usual.

BLACK WIDOW SPIDER. — This spider was very numerous throughout the southern interior of British Columbia, but no bites were reported.

BLOW FLIES AND FLESH FLIES.—Reports were received from northern Alberta of isolated cases of dermal myiasis caused by *Lucilia illustris* (Meig.) and *Musca* sp., and of intestinal or stomach infestation by psychodid larvae, *Fannia canicularis* (L.), and blow-fly larvae. There were also five cases of infestation by *Wohlfahrtia* larvae in humans, dogs, and a rat. *Cuterebra grisea* Clark was recovered from mice in Manitoba, and in Newfoundland, infestation of sheep by *Phaenicia sericata* (Meig.) was more general and widespread than in previous years.

CATTLE GRUBS.—In the interior of British Columbia, populations of both larvae and adults showed a marked increase. In Alberta, infestation was general and larval development about three weeks earlier than usual. In Saskatchewan, only a few infestations were recorded. In Manitoba, populations were normal and in eastern Ontario above average.

FLEAS.—*Ctenocephalides* spp. continued to be the cause of many inquiries from coast to coast. In Alberta the western chicken flea was recorded from Grassy Lake, the European chicken flea from Stettler, and *Orchopeas* sp. from mink at Faust. In Saskatchewan the European chicken flea attacked children at Hazlet and Clavet, and one infestation of the human flea was recorded.

HORN FLY.—In British Columbia severe infestations of the horn fly were reported from the interior and the insect was recorded from North Pine in the Peace River area. In the course of a survey it was found everywhere in Alberta, westward into the forests of the Rockies and as far north as the Peace River district, the northwestern limits being about Grand Prairie. In southwestern Ontario a survey of 179 farms revealed the fly to be a serious pest of livestock. In Prince Edward Island, populations were normal.

HORSE BOTS.—In southwestern Ontario, 33 of 46 horses examined after slaughter were found to be infested by both the horse bot fly and the nose bot fly.

LICE.—In the interior of British Columbia, an unusually mild winter favoured the buildup of a large population of lice on cattle.

In Saskatchewan, cattle lice were only occasionally reported and in Manitoba they were less numerous than usual. In southwestern Ontario, 87 per cent of the cattle examined in a survey were infested by the cattle-biting louse, the long-nosed cattle louse, and the short-nosed cattle louse, in decreasing order of abundance, most infestations being light. Also in this area, a survey revealed the hog louse to be present on 48 per cent of 179 farms inspected. At Lethbridge, Alta., one infestation of the crab louse was reportd.

MITES.—The chicken mite was reported from British Columbia, Saskatchewan, and Ontario, some household infestations emanating from birds' nests.

MOSQUITOES.—In the lower Fraser Valley, B.C., extensive flooding of river flats resulted in unusually large mosquito populations. Mosquitoes were very numerous also in the Kamloops area, but were destroyed by hot, dry weather early in the summer. In northern Alberta, summer precipitation was not sufficient to support a second brood. In Saskatchewan and Manitoba, mosquitoes were scarce because of scanty precipitation. In eastern Ontario, *Anopheles* spp. were more numerous than in recent years, but mosquitoes generally occurred in below normal numbers. In Prince Edward Island, populations were about normal.

POULTRY PARASITES.—A survey of poultry in southwestern Ontario revealed that approximately 75 per cent of the flocks were infested by various parasites.

SHEEP BOT FLY. — An examination of the heads of sheep and lambs at abbatoirs in southwestern Ontario revealed that 78 per cent contained larvae of the sheep bot fly.

SHEEP KED.—All but one of 34 flocks of sheep and lambs examined in southwestern Ontario were infested by the sheep ked.

STABLE FLY AND TABANIDS.—A survev of 179 farms in southwestern Ontario revealed the stable fly and tabanids to be serious pests of livestock.

TICKS.—In the interior of British Columbia, *Dermacentor andersoni* Stiles was about as abundant as usual, but there were only three cases of tick paralysis reported, two of them involving humans. The ear tick, *Otobius megnini* (Dugès), was somewhat less numerous than usual on game animals. In several herds of cattle examined, infestation ranged from 50 to 100 per cent of the animals, but no deaths were reported. The winter tick, scarce since the 1948 outbreak, was found in moderate infestations on cattle at Empire Valley and at 70 Mile in the Cariboo district. *Ixodes pacificus* Cooley and Kohls was numerous, at least in the Nanaimo and Alberni districts. In northern Alberta there were two records of *D. andersoni*, one on a child, and three records of *D. albipictus* (Pack.), one on a man and two on cattle. The latter species was recorded also at Moose Jaw, Sask. *D. variabilis* (Say) was found on a dog in Alberta, in several instances on dogs and children in Saskatchewan, and was reported as being

unusually abundant in Manitoba. It was collected also at Senneterre, Que., and was very numerous near Liverpool, N.S. The brown dog tick was recorded for the first time in Western Canada, at Vancouver, B.C. In Ontario, several infestations were reported at Ottawa and a few at Hamilton. *Ixodes cookei* Pack. occurred fairly commonly in the Ottawa, Ont., area and was reported from St. Martin, Que.

HOUSEHOLD INSECTS

ANTS.—Ants continued to be generally troublesome pests in dwellings. In the lower Fraser Valley, B.C., *Camponotus herculeanus modoc* Wheeler was more commonly reported than usual, and *Lasius niger* (L.) was involved in several infestations. In southwestern Ontario and Newfoundland, *Camponotus* spp. continued to be serious household pests, and in Ontarioi and Quebec, *Monomorium pharaoni* (L.) continued to spread and increase in numbers.

BOOKLOUSE.—In Ontario this insect occasionally developed in large numbers in new dwellings.

BORBORIDS.—*Leptocera* sp. appeared in large numbers in a basement at Bancroft, Ont., between window sash at Ottawa, Ont., and in a fish-processing plant and other buildings at Grand Bank, Nfld. In the last instance the insects developed in debris along beaches and invaded the town in tremendous numbers.

BOXELDER BUG.—In the interior of British Columbia, populations of this pest were the largest in many years. It was commonly reported also in Alberta and Saskatchewan, but was unusually scarce from Manitoba eastward to Newfoundland, no infestations being recorded in most areas.

CARPET AND HIDE BEETLES. — At Victoria, B.C., *Anthrenus verbasci* (L.) and *A. scrophulariae* (L.) were involved in over 150 inquiries. On the mainland of the Province, *Attagenus piceus* (Oliv.) and *A. scrophulariae* were commonly reported, *A. verbasci* being restricted mainly to coastal areas. From Alberta eastward to New Brunswick, *A. piceus* was the principal species and in most areas the most common and injurious household pest. *A. scrophulariae* was much less numerous in this area, but was the most common species in Prince Edward Island. At Saskatoon, Sask., *Dermestes maculatus* DeG. was recorded for the first time in the Province, being found in cold air ducts in three dwellings.

CLOTHES MOTHS.—Clothes moths, mainly *Tineola bisselliella* (Hum.), occurred commonly from coast to coast, but reports were nowhere numerous.

CLUSTER FLY.—Reports were received only from Ontario and Quebec, where the insect, although rather less numerous than usual, was still a troublesome pest.

COCKROACHES.—The German cockroach was commonly reported in all provinces. In Alberta and Ontario, the brown-banded roach continued to spread and increase in numbers. *Parcoblatta pennsylvanica* (DeG.) was a pest mainly in motels and summer cottages in the Laurentian areas of Ontario and Quebec. *Blatta orientalis* L. and *Periplaneta australasiae* (F.) were occasionally reported. *Panchlora* sp. was recorded once, in Edmonton, Alta.

CRICKETS.—*Ceuthophilus* spp. were occasional pests in Saskatchewan and Manitoba, and fairly common in northern Ontario and Quebec.

HOUSEFLY.—Although not frequently reported, this insect continued to be a major pest, increasingly so where resistance to DDT had developed.

HOUSE CENTIPEDE.—This predator was recorded several times in Ontario and was fairly numerous in a section of the National Museum at Ottawa.

MILLIPEDES.—Unusually large numbers of millipedes occurred in southern Ontario. In most areas, however, reported infestations were restricted mainly to basements.

MITES.—After a year of comparative scarcity in Canada, the clover mite became very numerous in the Prairie Provinces. Smaller increases were indicated in Ontario and Quebec. Home invasions were commonly associated with grass seeded close to foundations. At Ottawa, Ont., three household infestations of the chicken mite were reported, apparently having their origin in birds' nests.

PLASTER BEETLES.—In Quebec, *Corticaria* sp. and *Cryptophagus* sp. occurred in a severe mixed infestation at Granby, and the former occurred at Windsor Mills.

SILVERFISH.—Silverfish were widely distributed and occurred fairly commonly.

SPRINGTAILS.—Infestations in the soil of potted plants and in well water were common.

SQUASH BUG.—This insect entered several dwellings in the vicinity of Vernon, B.C.

STRAWBERRY ROOT WEEVIL.—Adults of this insect were generally troublesome in human habitations, being especially so in northern Alberta and Ontario.

WOOD BORERS.—Various species of powder-post beetles commonly damaged flooring in dwellings and structural wood in barns and other buildings, mainly in the vicinity of the Great Lakes and in coastal areas. *Lyctoxylon japonum* Reit. was found at Winnipeg, Man., in bamboo venetian blinds from Japan. The wharf borer was reported from Montreal, Que., and at Ottawa, Ont., a severe infestation developed in a church. The termite *Zootermopsis angusticollis* (Hagen) seriously damaged many older buildings in the lower Fraser Valley, B.C., and a flat-headed borer, *Callidium violaceum* (L.), extensively damaged a house at St. Marys, Nfld.

STORED GRAIN INSECTS. — In terminal elevators at Vancouver, B.C., the moths *Hofmannophila pseudospretella* (Staint.) and *Endrosis sarcitrella* (L.) continued to be the most commonly encountered pests. Other insects present in smaller numbers included the yellow mealworm, the Indian-meal moth, the granary weevil, the spider beetle *Ptinus ocellus* Brown, the tobacco moth, and the European grain moth. The last two had not been recorded for six years. Mites and psocids were also encountered. In elevators at Creston and Wyndell a few black carpet beetles were found in addition to many of the pests already listed. There were no serious outbreaks. In the Prairie Provinces there were fewer insect infestations in stored grain than in several previous years, partly because much stored grain had been transferred from annexes to elevators. Pests encountered frequently in grain and empty granaries included grain mites, the rusty grain beetle, collembola, psocids, and the plaster beetle *Lathridius minutus* (L.). Others found less frequently included the red flour beetle, the hairy spider beetle, various dermestids and staphylinids, the granary weevil, the yellow mealworm, the saw-toothed grain beetle, the foreign grain beetle, *Tribolium madens* (Charp.), and anobiids. *Trogoderma parabile* Beal was recorded for the first time in Saskatchewan when it was found in stored samples of seed wheat at Saskatoon and in several feed mills in the Province.

MILL AND WAREHOUSE INSECTS. — In the interior of British Columbia the most common pest in mills and warehouses continued to be the black carpet beetle. Other pests that occurred fairly commonly included the spider beetle *Ptinus ocellus* Brown, the yellow mealworm, the Mediterranean flour moth, and the moth *Hofmannophila pseudospretella* (Staint.). Species found less frequently included the granary weevil, the cadelle, the mealmoth, the Indian-meal moth, the larder beetle, the confused flour beetle, the varied carpet beetle, the saw-toothed grain beetle, the pyralid *Aphomia gularis* Zell., the moth *Endrosis sarcitrella* (L.), the European grain moth, the broad-horned flour beetle, the drug-store beetle, and a few others of minor importance. In the Prairie Provinces the confused flour beetle was the species most commonly found in flour mills. Other insects occurring in smaller numbers in mills and warehouses were the yellow mealworm, the Mediterranean flour moth, the beetle *Cryptolestes turcicus* (Grouv.), the hairy spider beetle, the saw-toothed grain beetle, the cadelle, the larder beetle, the Indian-meal moth, the black carpet beetle, the granary weevil, *Tribolium madens* (Charp.), the red-legged ham beetle, *Tribolium destructor* Uytten., silverfish, and a tenebrionid *Cynaeus angustus* (Lec.) of rare occurrence. In Quebec, *Ptinus* spp. were troublesome in warehouses, and in Prince Edward Island the saw-toothed grain beetle was the main pest.

FOOD-INFESTING INSECTS.—As usual, insect and related pests in retail stores and kitchen cupboards were varied, numerous, and troublesome. The following were important pests in all provinces: the larder beetle, the saw-toothed grain beetle, the Indian-meal moth, the drug-store beetle, various flour beetles, and spider beetles. Occurring rather less commonly were the cigarette beetle, *Ephestia* spp., the mealmoth, the bean weevil, the yellow mealworm and the cheese mite. The larder beetle was a major pest in Alberta and Quebec, and was extremely troublesome in Newfoundland. As Saskatoon, Sask., *Perimegatoma vespulae* Mill., not previously recorded in the Province, destroyed many boxed insect specimens and Riker mounts. At Halifax, N.S., *Dermestes frischii* Kugel was recorded for the first time east of Ontario when it developed in considerable numbers in a fish meal plant. In Newfoundland the spider beetle *Ptinus ocellus* Brown was unusually troublesome.

(Accepted for publication: May 12, 1959)

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VI. THE SOCIETY

PROCEEDINGS OF THE NINETY-FIFTH ANNUAL MEETING

29 October - 1 November 1958

A joint meeting of the Entomological Society of Ontario and the Entomological Society of Canada was held at the Ontario Agricultural College, Guelph, Ontario, on the 29th, 30th, 31st of October and the 1st of November 1958. On the afternoon of the 31st October and morning of 1st November members of both societies met with members of the Agricultural Chemistry Subject Division of the Chemical Institute of Canada in a jointly sponsored symposium.

This marked the 95th Annual Meeting of the Entomological Society of Ontario and the 8th Annual Meeting of the Entomological Society of Canada. The meeting was opened by the President Mr. G. G. Dustan at 10:00 a.m. in War Memorial Hall.

The President introduced Dr. J. D. MacLachlan, President of the Ontario Agricultural College who welcomed the two societies to the College. Mr. G. P. Holland, President, Entomological Society of Canada then took the chair and introduced the guest speaker Dr. D. K. McE. Kevan of Macdonald College, Quebec.

The meeting then proceeded as per programme.

The Annual Business Meeting was held in War Memorial Lounge on 30th October 1958 at 1:45 p.m. A total of 42 members attended. On a motion by H. R. Boyce and D. G. Peterson the minutes of the previous annual meeting were adopted as read.

New Board:

The President then announced the results of the mail ballot which was conducted during 1958 showing the Board of Directors for 1959 to be:—J. A. Begg, T. Burnett, D. M. Davis, A. M. Heimpel, J. A. McAlpine, A. G. McNally and D. G. Peterson. He suggested that this group meet as soon as possible to elect from amongst themselves, President and Vice-President according to Constitution.

Finances:

The financial statement for the year ending 20th October 1958 was presented by the Secretary-Treasurer. On a motion by W. C. Allan and H. R. Boyce the statement was accepted. It was also decided that C. J. Payton and R. E. Saunders be retained as auditors.

Grant to Entomological Society of Canada:

After some discussion it was recommended that a grant of $125.00 be made to the Entomological Society of Canada.

Annual Fees:

The President outlined the policy at present and explained that one fee took care of membership in both societies and that the Ontario Society collected such fees. However, because of the wording of our Constitution, it was difficult to make any changes in fees unless the Canadian Society held its business meeting before ours. He stated that he had been assured that the Canadian Society was not contemplating any change in fees for the coming year and suggested that this matter be taken under consideration by the new Board of Directors. It was moved by D. G. Peterson and G. S. Cooper that the fees for the coming year be $2.00 for the Ontario Society and $6.00 for the Canadian Society. A total of $8.00 — carried.

Publications:

The President stated that it was deemed advisable to continue our close affiliation with the Canadian Society and with this in mind a committee had been formed to enquire into and report upon the relationship between the two societies with regard to publications.

This report was quite lengthy and as many of the points discussed necessitated changes in the Constitution, it was suggested that the incoming board look into the matter of having a conference with the Canadian Society with the idea of bringing all phases of publication into line with the existing requirements. A discussion as to the future purpose of the Annual Report then took place and it was suggested that nothing be done by way of change until the whole publication procedure was thoroughly discussed with the Publications Branch of the Province of Ontario. The President pointed out that it may be expedient to form two committees, one from each society to look into this matter and approach their respective boards with clear cut ideas as to changes. G. F. Manson pointed out that while the Joint Publication Committee had originally been formed to maintain recognition of our Society, perhaps the time had come when we should consider having publications published in one journal. It was generally felt that this Society would prefer to maintain the Annual Report and the President explained that the Annual Report can and should take articles which cannot be published in the "Canadian Entomologist". He also pointed out that this was part of the material which would be passed on to the new board.

Appreciation:

The President then thanked all members of the local and the programme committees for a very fine effort in helping to make the meetings a success and he particularly paid tribute

to the effort of Mrs. A. G. McNally for the organization and carrying out of the Ladies' Programme.

Resignations:

The President then announced that the resignation of A. J. Musgrave as Editor of the Annual Report had been received with regret and he expressed the sincere appreciation of the Society for the splendid work which Dr. Musgrave had done during the past three years.

Annual Meeting 1959:

It was announced that an invitation had been accepted to meet with the Entomological Society of America in Detroit in 1959 and that complete details would be on hand very soon. It is understood that the Entomological Society of Canada has also been invited to join in this meeting.

New President:

Mr. Dustan announced that as a result of voting by the new board of directors A. G. McNally had been elected President for 1959 and D. G. Peterson Vice-President.

Nominating Committee:

A nominating committee consisting of G. G. Dustan, T. A. Angus and G. F. Cooper was announced and the chairman asked that this group submit the names of eight members for Board of Directors for the 1960 season. This list, and any other names which may be added, would constitute a mail ballot.

The President then thanked the members for the support which had been given to him during his term of office and extended his best wishes to the new officers.

The business meeting then adjourned at 2:38 p.m.

Paper reading continued during next day and on Saturday November 1st, 1958 a symposium sponsored jointly by the two Entomological Societies and the Chemical Institute of Canada was conducted.

The meeting was closed at noon on Saturday, November 1st, 1958.

W. C. Allan,
Secretary-Treasurer.

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FINANCIAL STATEMENT
1957-58

RECEIPTS

1. Dues	$1,169.00
2. Back Numbers	23.36
3. Reprints	311.50
4. Interest	15.00
5. Grants	306.00
	$1,824.86
Bank Balance 18 Oct. 1957 (less O.S. Cheque)	$ 375.03
	$2,199.89
Bonds—18 Oct. 1957	$ 400.00

EXPENDITURES

1. Dues to Can. Ent. Soc.	$ 922.00
2. Grant to Can. Ent. Soc.	125.00
3 Exchange	2.80
4. Library Insurance	22.50
5. Binding	6.50
6. Honorarium	100.00
7. Postage	70.00
8. Envelopes and Printing	29.03
9. Programs—badges, tickets	70.33
10. Letterhead	16.35
11. Reprints	260.00
12. Speakers Accommodation	10.30
13. Food Service	42.50
14. Janitor Services	5.70
15. Incidental Expenses	45.00
16. Telegrams	2.10
17. Auditors	5.00
18. Transport Charge	1.00
19. Steno. Services	30.00
20. Brief Case	20.10
	$1,786.21
Bank Balance 20 Oct. 1958	$ 413.68
	$2,199.89
Bonds—20 Oct. 1958	$ 400.00

Auditors
B. E. Saunders
C. J. Payton

W. C. Allan,
Secretary-Treasurer.
20th October 1958.

VII. INDEX

INDEX

Section V is not included in this Index.

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AUTHORS' GUIDE

1. Contributions should be submitted to the Editor, and should not have been or should not subsequently be published elsewhere.

2. Two copies of each manuscript are required. Manuscripts should be typed double spaced on paper 8½ x 11 inches, leaving ample margins. The first page should contain only the title, the author's name and address, and footnotes to these. Tables and illustrations should be placed on separate pages at the back of the manuscript. One extra copy of each illustration should accompany the manuscript. A summary is required for all but very short papers. Authors should refer to papers in this volume for guidance on arrangement of material.

3. Place references in a list typed double spaced on a separate sheet of paper at the end of the text. Arrange them alphabetically by the author's last name followed by the author's initials, year (in parenthesis), title, name of publication (abbreviated as in the *World List of Scientific Publications),* volume number, and number of the first page. For example:

(14) DOE, J. and DOE, M. (1888). Some observations on cockroaches. Rep. ent. Soc. Ont. 5: 46-49.

Books should be listed as follows: author, date, title, edition, publisher, and place of publication.

4. All organisms should be supplied with scientific name and authority, as well as common name, if approved.

5. All chemicals should be given their common names, if approved. Chemical names, as given in *Chemical Abstracts,* should be stated, preferably in footnotes to tables, otherwise in parenthesis when the chemicals are first referred to in the text. Brand names and the names and addresses of the manufacturers should be given in footnotes to tables when appropriate.

6. Correspondence concerning, and orders for reprints should be addressed to the Secretary-Treasurer, Entomological Society of Ontario, Ontario Agricultural College, Guelph, Ontario.